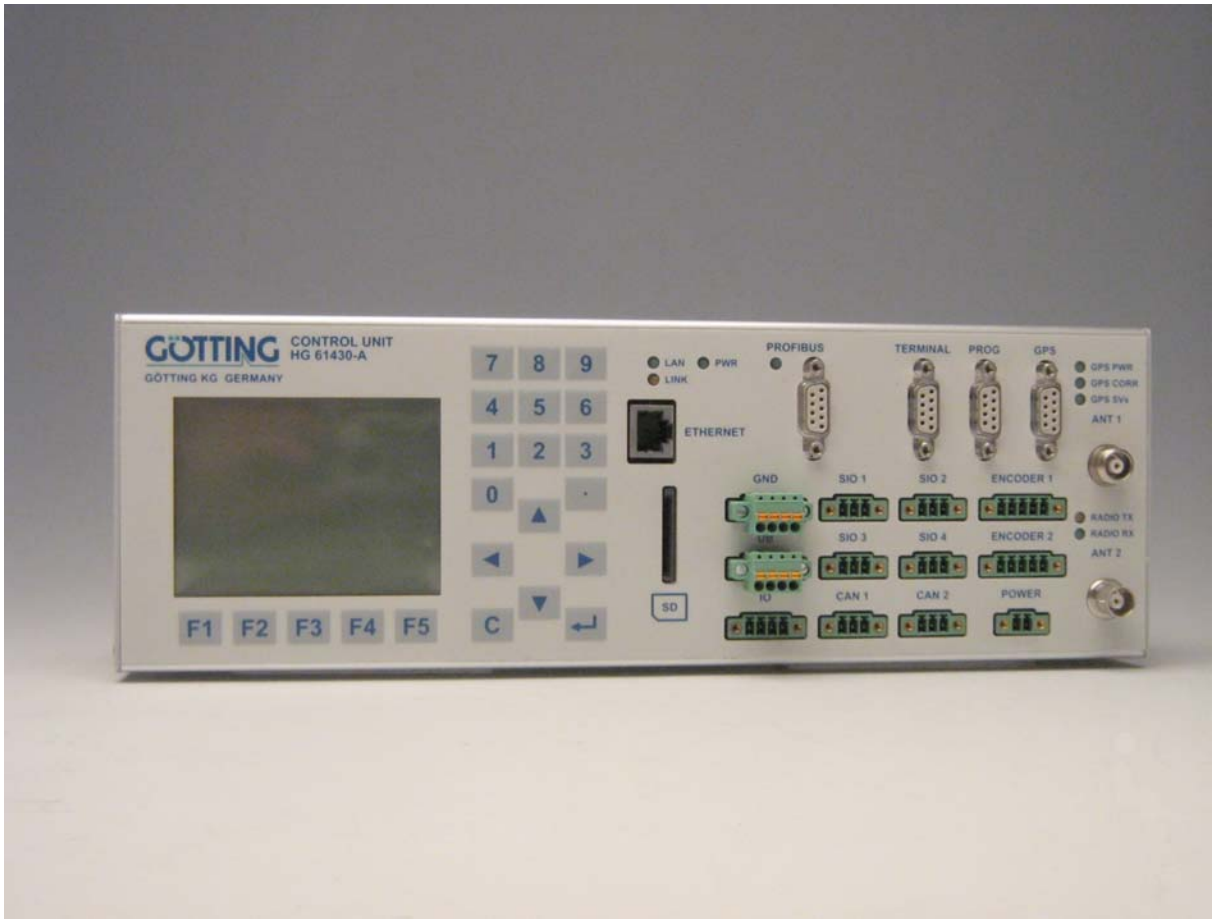

Track Guidance Controller

Basics, Commissioning and Software

HG 73650

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1 Introduction

The subject of this manual is the track guidance controller for AGV (Automated Guided Vehicles) used for following virtual tracks (see below). This manual describes the following components of the track guidance controller:

1. Track control with steering controller, sensor fusion and vehicle control (see chapter 2 on page 10)
2. Overview of interfaces (see chapter 3 on page 25)
3. Commissioning (see chapter 4 on page 28)
4. The description of the hardware and the telegram listing of the interfaces can be found in two separate documents

The following sections of the introduction will provide an overview of these areas.

1.1 Virtual tracks

A virtual track describes a route that does not have physical tracks or marks (e.g. optical lines or inductive guide wires). It is usually defined in a CAD program (below we will refer to *Malz++Kassner CAD 6* for which Götting KG provides a plug-in for the track guidance controller) where the required track is directly drawn into a layout. The vehicle will follow this virtual track like on a real track or rails. The CAD software has to reflect the features of the vehicle used (see below) in order to make tracking as accurate as possible.

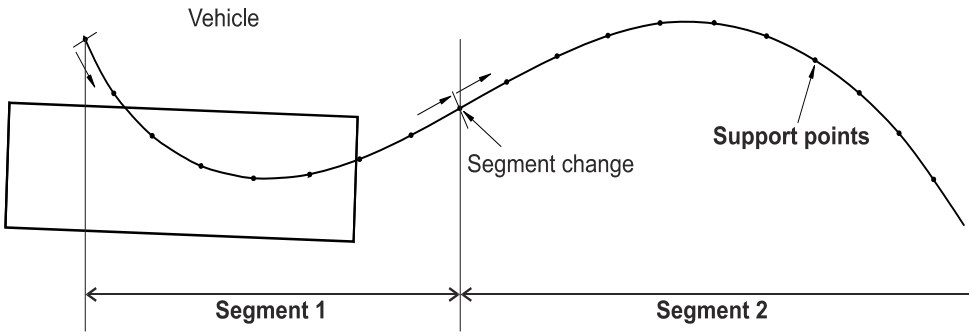


Figure 1 Example: Virtual track with support points

The virtual track consists of several segments that define the sections between branches and end points. Each of the segments must consist of at least four support points which are positioned at equal distance over the whole route. These support points are not actual points on the route (for example transponders in the ground). The distance between them depends on the type of the route and the vehicle used. The closer the support points lie next to one another the more precisely the tracking will correlate with the virtual track. However, very close distances between the points are unnecessary for large vehicles because the vehicle itself cannot drive that accurately. Should the distances between the points be too long, the CAD software would display them as polygonal curves because no rounded curve can be calculated from points which are wide apart from one another.

1.2 Suitable and unsuitable vehicle types

The range of particularly suitable vehicle types covers all vehicles that either have a fixed axle or symmetrical steering. Vehicles such as trucks, forklift trucks, electric tow tractors and some heavy-duty transporters fulfill these requirements. A fixed axle can be applied to the axis of symmetry without the problem of dragging wheels in curves.

Figure 2 Example: A selection of vehicle types

The sketch below shows simplified versions of all vehicles as three-wheelers, because this is the base vehicle model used by the track guidance controller. For example also a car is only steered from one point, so the computer can consider it a three-wheeler. Both wheels on the front axle follow a specified steering angle. The track guidance controller can also be used for vehicles where the steered wheel is not in the middle (e.g. some fork-lift trucks).

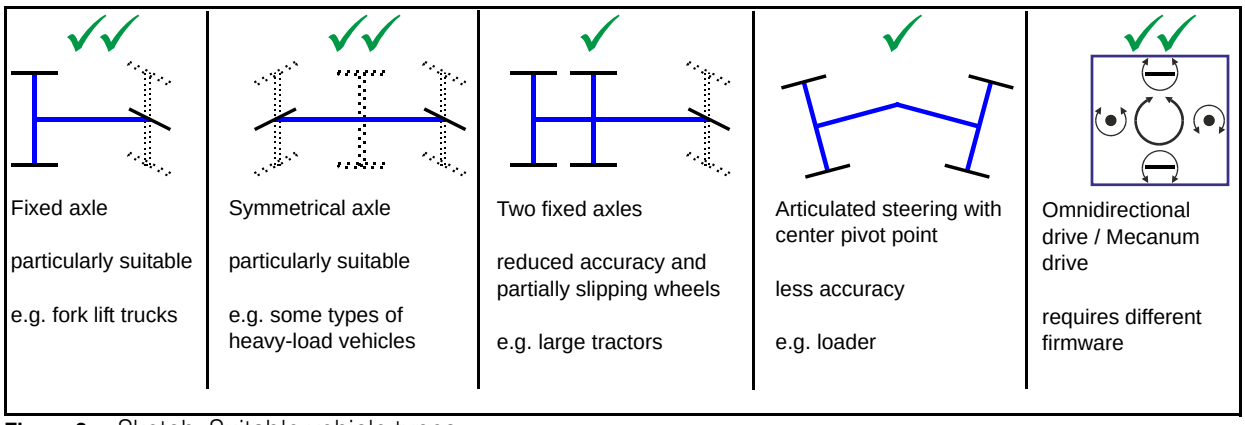


Figure 3 Sketch: Suitable vehicle types

The further the actual vehicle diverges from the typical three-wheeler model (e.g. center-pivot steered vehicles such as front loaders where the distance between the axles varies when turning), the less precise the tracking will be. Omnidirectional vehicles are also suitable, but require a different firmware than the three-wheeler models.

1.3 How it works

1.3.1 System Structure

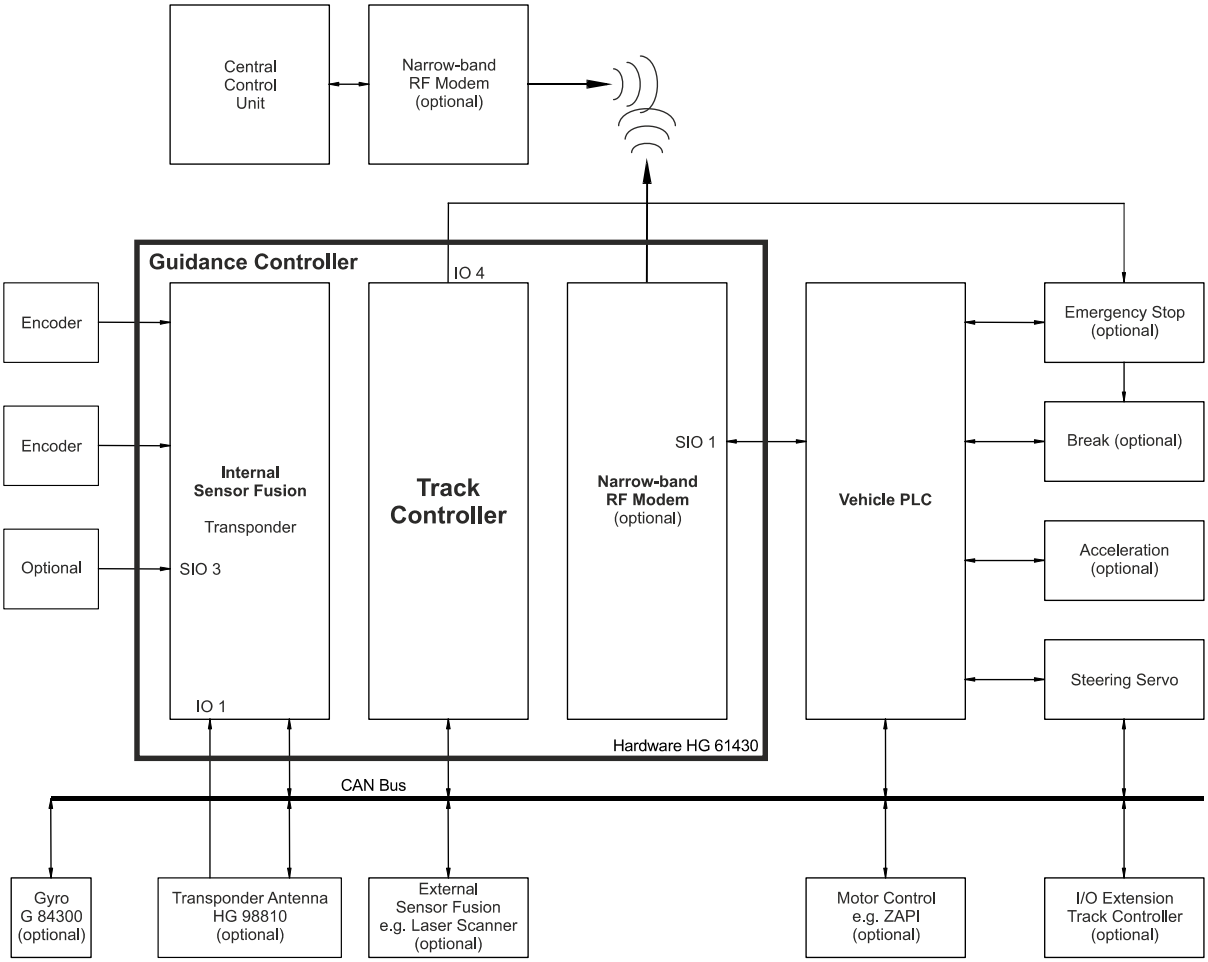


Figure 4 System Structure

Due to the strict separation of steering controller, sensor fusion and navigation system as well as the smart interaction with vehicle controller the track guidance controller offers a high degree of flexibility and is suitable for monitoring safety-critical vehicle components.

1.3.2 Steering Controller

The track guidance controller includes the steering controller which calculates how to guide the vehicle from the current position to follow the track. The steering controller's outputs are

- nominal steering angle
- nominal vehicle velocity
- various additional parameters / information

Some steering servos and motor controller can be directly controlled by the steering controller so that a vehicle control unit is not required in every application. Related to monitoring, redundancy and customized modifications to the vehicle, a **vehicle control unit** (e.g. PLC) is recommended for large vehicles.

If emergency stop devices are to be used, a vehicle control unit must be used in combination with the track guidance controller to ensure maximal safety.

1.3.3 Sensor Fusion

The steering controller receives information from the sensor fusion about the position. The sensor fusion can be connected internally (preferably when navigating with transponders or Sky Trax Tags) or externally (e.g. in the case of a laser scanner). The sensor fusion provides the steering controller the following data (called **pose**):

- position on X coordinate
- position on Y coordinate
- velocity
- angle

The sensor fusion establishes these values based on the data of the connected sensors (e.g. transponder antennas, laser scanners, GPS system). If required, systems with physical guidance tracks can be integrated (e.g. inductive guide wire, optical guidance).

There is a selection of different odometric sensors available, such as incremental / rotary encoders. Optionally the accuracy and load-dependence of the odometry can be enhanced by using the Götting Gyro HG 84300. It is also possible to calculate the odometry from two sources and compare their results. This way, the sensor failures can be identified.

1.3.4 Track Controller

The task of the track guidance controller is to move the vehicle from the current position (given by the sensor fusion) to the next support point. The controller also calculates the rest of the track along several support points (it forms what are known as regressions) and delivers the virtual track that the vehicle can drive on.

The tracks between the support points are reconstructed with smooth functions (regressions over several support points) so that a continuously controlled movement of the vehicle is possible. The values of position, accuracy, 16 free and 16 defined bits are stored at each support point.

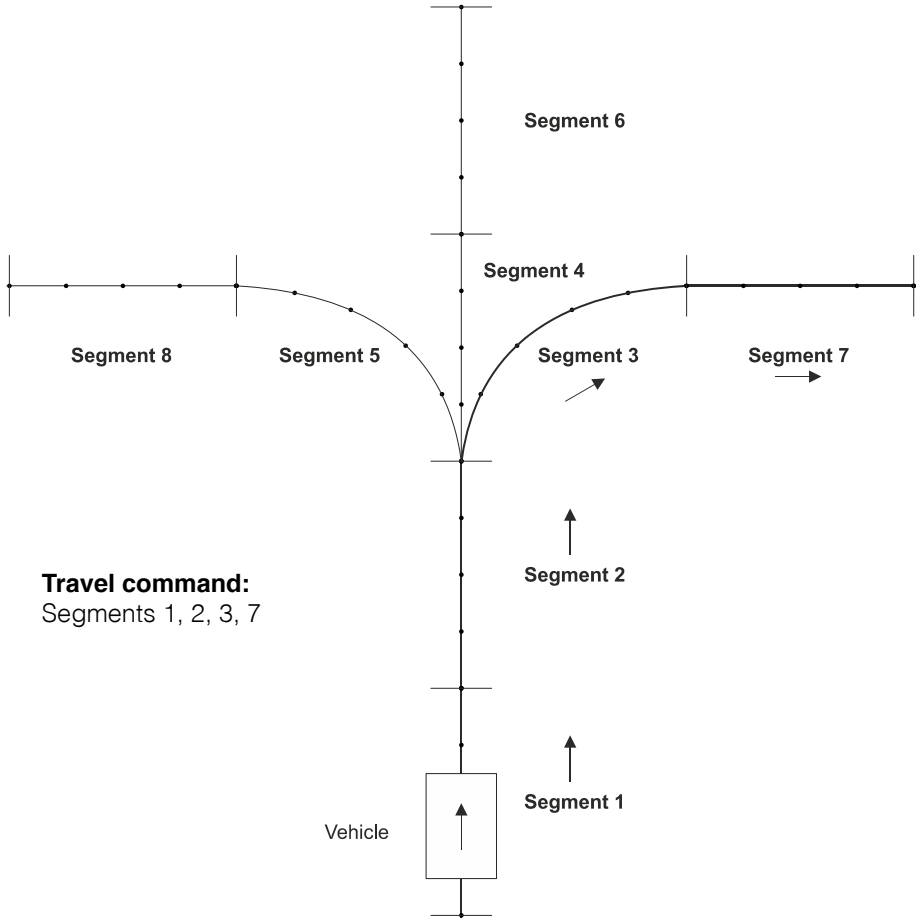


Figure 5 Exemplary layout with travel commands as a combination of segments

The vehicle can be placed between the support points. The track controller uses the incoming position data to identify what segment it is on and which support point follows next. The tracks to be driven on are defined from a combination of segments that for example state where the vehicle has to turn. A travel command can be entered at the central control unit, the vehicle control unit or directly at the steering controller.

1.3.5 Parameterization

An RS 232 interface is provided to set the parameters and to commission the vehicle. It can be connected to a PC/ laptop with a serial interface and a terminal program. This interface can be used to monitor and record driving conditions (e.g. for debugging purposes) and to set, import or export driving parameters. Transponder and, marker lists as well as segments can be exported, imported and displayed. This interface can also be used to update the internal operating software on the track guidance controller.

A display with a foil keyboard is integrated into the steering controller in order to enter the segments and show status information.

1.4 Preconditions / Options

- If the internal sensor fusion is to be used, at least one incremental / rotary encoder must be used. Please ensure that this is a push/pull type with output voltage of 5 to 25 V and two tracks perpendicular to each other.
  Depending on the odometry, the Gyro **HG 84300** can also be used to improve accuracy and for redundancy.
- If a transponder system is to be used, the **HG S71720** system can be connected via the CAN bus. ID 250 transponders can be used at a reading height of up to 10 cm. The Sky Trax System can be used as an alternative or in combination with the transponder system.
- When using the **HG 43600** laser scanner at least one incremental encoder must be directly connected to the track guidance controller. If the **HG S57652** GPS system is to be used, the rotary encoders must be connected to the GPS controller.
- To extend the input and output capabilities, the IFM module CR 2033 can be connected via the CAN Bus.

2 Guidance Control in Detail

The structure of the track guidance controller is shown in Figure 4 on page 6. Two incremental encoderscan be connected to the steering controller hardware. This is required when:

- the internal sensor fusion is used and the steering controller has to control or monitor the velocity itself or
- where a laser scanner is used.

If the internal sensor fusion is used, the position of the vehicle is calculated from the odometry provided, initialized and adjusted by the transponder antenna and/or the Sky-Trax system. The transponder antenna is then connected via the CAN bus. Additionally the position impulse (impulse when the midpoint of the antenna crosses the transponder) has to be connected with IO 1. The Sky- Trax system is connected via the SIO 3.

The optional gyro is connected via the CAN bus. Its purpose is to improve the odometry. As some odometric calculations tend to be dependent on load, we recommend the integration of the gyro.

If an external sensor fusion is to be used (to identify position and angle), it can be connected to the CAN bus. The applicable protocol is specified in the reference manual supplied.

External sensor fusions can be for example laser scanners (**HG 43600**) or GPS (**HG S57652**). Other position identification systems can be used as long as they comply with the CAN bus protocol (see reference manual).

2.1 Steering controller

The purpose of the steering controller is to guide the vehicle on the track. It needs information about which track to drive on and the current position of the vehicle. The central control unit tells the steering controller what segment to drive on. The segments were generated in the CAD software (see below) represented by their support points. Using the current vehicle position and angle the relation to the segment is known. Then the steering angle and vehicle velocity can be calculated.

2.1.1 Segments

Segments are the connecting paths between branches and end points. The routes are compiled from these segments from the start to the finish.

Example A small area has four stations. To move the vehicle from the station 1 to station 3, the vehicle has to pass segments 4, 5, 8 and 9. To return to station 1 (with the same vehicle orientation), the vehi-

cle has to go through segments 10, 1, 7, 6 and 3. Since the vehicle drives backwards along segments 6 and 3, the velocity of the segments is negative (see also Figure 7 on page 12).

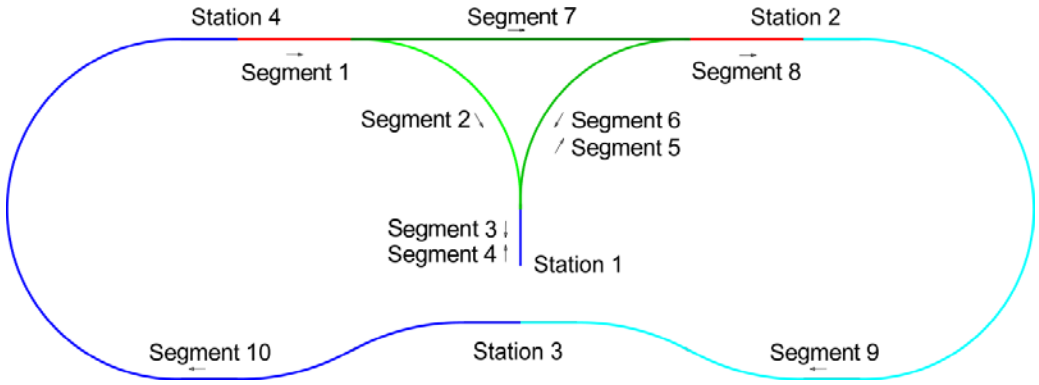


Figure 6 Example: Segments

2.1.1.1 The segment file

All segments and the associated support points are stored in the segment file. This segment file is created with a CAD software (*Malz ++ Kassner CAD6*). The typically large CSV file, created by the CAD software, must be compiled into a binary format using *BRTool*. The *BRTool* software is available from us on request. BRTool also allows you to directly edit individual support points and their critical attributes such as velocity without having access to *CAD6*.

Each row of the segment file represents one support point. It contains the support point's coordinates, two velocities and an attribute field.

```
3;304;8920;2164;10;10;0x00000000
3;305;8920;1914;5;10;0x00000000
3;306;8920;1665;1;10;0x00000002
4;1;8920;1665;10;10;0x00000001
4;2;8920;1416;10;10;0x00000000
4;3;8920;1167;10;10;0x00000000
```

Segment number	Point number	X Position	Y Position	Velocity end	Velocity next	Attribute
3	304	8920	2164	10	10	0x00000000
3	305	8920	1914	5	10	0x00000000
3	306	8920	1665	1	10	0x00000002
4	1	8920	1665	10	10	0x00000001
4	2	8920	1416	10	10	0x00000000
4	3	8920	1167	10	10	0x00000000

Table 1 Explanation of a segment list with support points

Each row of this table is one support point. The first column contains the segment number to which the support point belongs to. The second column contains the support point number. Columns 3 and 4 contain the X and Y coordinates of the support point in mm. Columns 5 and 6 contain velocity data in dm/s. There are two velocities because on the one hand a connecting segment could exist, or the vehicle is to be stopped at the end of the segment. Therefore, where the last segment is concerned or the vehicle changes direction column 5 is automatically selected. If a connecting segment exists column 6 is selected.

The velocities are interpolated linearly depending on the position between the support points so that a continual velocity profile is created. Only at the end of the last segment (or if the direction of travel changes or an error occurs) will the velocity be set to 0.

NOTE! Always allow the velocity to end with 1, because if you pick 0 the vehicle will stop before reaching the end of the segment.

If the velocity is negative, the vehicle travels backwarts on the segment. The vehicle always moves towards the support points (from the start of a segment to the end). This means that when the vehicle is first to be driven in one direction on a track and then to be reversed (e.g. when docking on and off a ramp) there must be two segments for the same path.

The attribute field is located in column 7. The attribute is subdivided into 16 higher an 16 lower bits. The lower bits refer to internal functions of the guidance controller. See the reference manual for further detail. The 16 higher bits are freely available and are passed to the vehicle control unit.

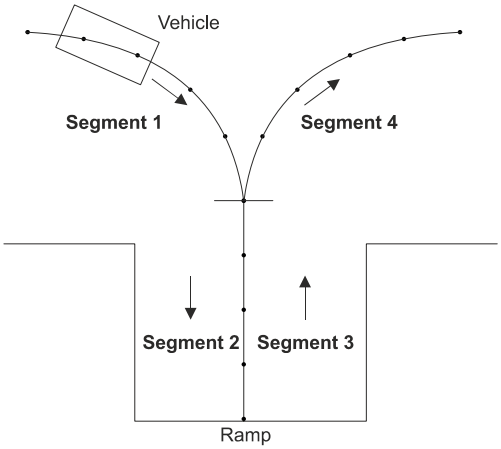


Figure 7 Example for congruent segments

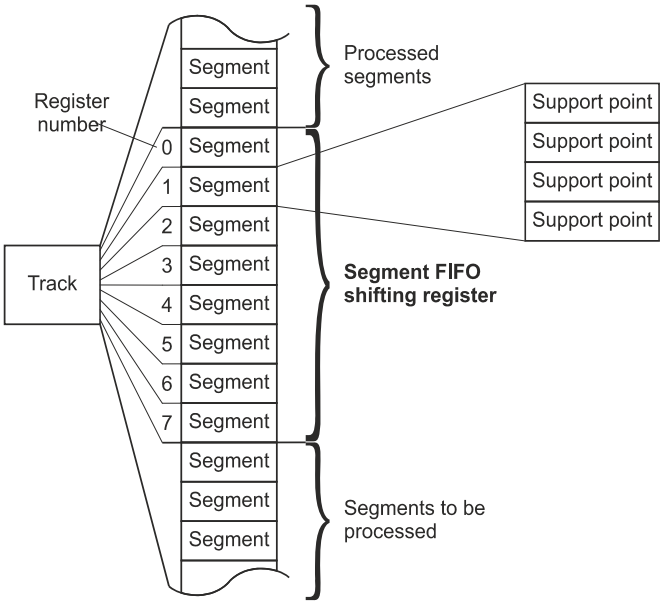


Figure 8 Segment FIFO shifting register

2.1.1.2 Segment search

When the guidance of the vehicle is initialized, only one position of the vehicle is known at first. To identify the currently drivable segments and to transmit them to the central control unit, a segment search can be carried out. During the segment search, the track controller tests all the segments stored for drivability. The segment search can take several seconds depending on the number of segments. It is triggered by setting bit 4 in byte 1 of CAN Box 0x194. The steering controller must be in "waiting" mode (stand-by). On completion bit 5 in byte 1 in the CAN box 0x185 will be set (segment search completed). The positively found segments are transmitted as a segment listing in box 0x195 to the vehicle control unit. If the „segment-search"-bit is set to 0, the current segments will be transmittet in the segment list of box 0x195.

2.1.1.3 Specifiying the segments

The vehicle control unit specifies the segments to the steering controller via CAN bus. For testing purposes, they can also be specified via a terminal program or the keyboard. To ensure that continual driving is possible, the connecting segment must always be known. Therefore the steering controller has a segment memory with eight entries designed asa FIFO (First in First Out) shift register (see Figure 8 above). Segment 0 is the current segment. Segment 1 is the next segment. Segment 7 is the last segment in the FIFO register: If the FIFO register does not have 8 segments, the rest of the entries are filled up with 255 (Note: 0 is a valid segment number). If the vehicle is finished with a segment, it is pushed out of the FIFO register and the next segments move up.

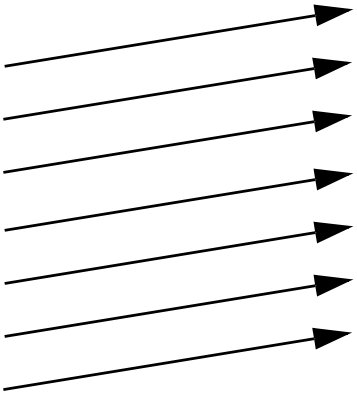
Before		Example: Segment number 33 just processed	After	
FIFO	Segment		FIFO	Segment
0	33		0	10
1	10		1	17
2	17		2	105
3	105		3	255
4	255		4	255
5	255		5	255
6	255		6	255
7	255		7	255

Table 2 Example: Shifting of segments - part I

The list will be transferred to the vehicle controller via CAN bus. The vehicle controller can respond to the removed segment, by moving a new segment into the FIFO register.

Before			After	
FIFO	Segment		FIFO	Segment
0	10	Segment number. 55 reloaded	0	10
1	17		1	17
2	105		2	105
3	255		3	**55**
4	255		4	255
5	255		5	255
6	255		6	255
7	255		7	255

Table 3 Example: Shifting of segments - part II

In this way more than 8 segments can be driven without stopping. In order to connect the segments consecutively, the terminal position of one segment always has to be the starting position of the next one.

NOTE! In order to prevent the steering controller from reloading a segment currently being changed by the vehicle control unit (the revolution period from "reading the list" to "list stored" can take one second), never edit the next segment (FIFO register number 1). Instead edit the segment with FIFO register number 2.

2.1.1.4 Transmission of the segments

Usually the segments will be transmitted with the CAN bus. For test purposes the segments can be entered using the keypad (membrane keyboard) or via a terminal interface. For more detailed information see chapter 4 „Commissioning“ on page 28.

The steering controller receives the segments in the CAN box with the identifier 0x194. The structure of the box is described in the reference manual. This box only contains one element of the buffer, wich is `Number of segment (LowByte)` and `Number of segment (HighByte`. The segment numbers will be transferred as unsigned int (16 bit), but internally only 8 bit will be used. If a 16 bit addressing is required, there is no need to change the communication.

To place the segment correctly into the FIFO register, the register number will be transferred as well (`Position of segment number in table`). The steering controller will be called up every 50 ms. Therefore the transmission of the list takes at least 8 x 50 ms = 400 ms. This list always has to be transferred in ascending order. To prevent double transmission within 50 ms (one message would get lost and the whole table would be invalid) there is the toggle bit. If the vehicle controller sends a box, the status of the first bit in byte 1 of the CAN box will be changed previously. The next box should not be transmitted before Box 0x195 (response of the steering controller) has reached the same status. The `target segment` is the last segment to reach the end of a desired route. The target segment does not necessarily have to be part of the FIFO register.

The CAN box of the answer by the steering controllerhas a similar structure. This box indicates the current status of the segments in the steering controller.

2.1.2 Attributes

If the vehicle is driving in automatic mode, the corresponding attributes are carried out when a certain support point is reached (e.g. turn signal, horn etc.) The 16 lower bits have a specific predefined meaning and are transmittet. The function of these bits are specified in the reference manual. The upper 16 bits are transmittet in CAN box 0x191 byte 5 and 6. For most attributes sufficient information is disclosed in the annex. The only exception is offset driving.

2.1.3 Offset driving

Constantly driving on the same track can lead to a strong deformation of the surface structure (e.g. asphalt). For some plants it is appropriate therefore to vary the route by a few centimeters. However, the track may only be moved so far that it is still possible to read the installed transponders. For transfer stations / end points the offset has to be switched off.

Segment 0 in the steering controller can be used as a version number of the segment file. Segment 1 is the transition for offset driving on the left. Segment 2 serves as a transition for offset driving on the right. Both segments have to start with the coordinates X = 0 and Y = 0. The X direction is the longitudinal direction. The Y direction represents the offset to the actual track.

The segments should be as short as possible. Segment 3 is the return from the left offset to the actual track. Segment 4 is the return from the right offset to the actual track.

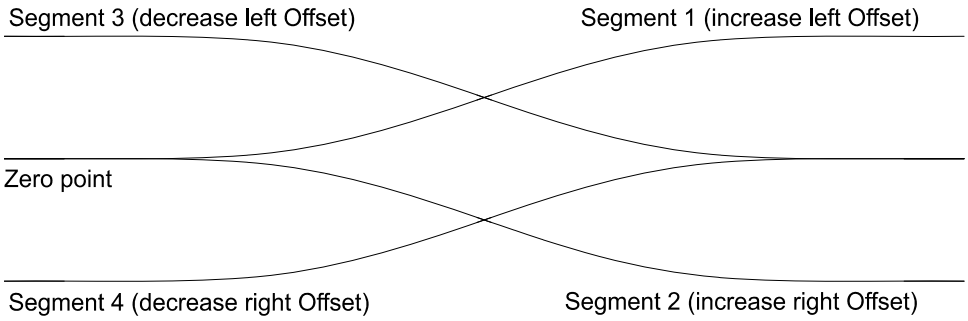

Segment 3 (decrease left Offset)
Segment 1 (increase left Offset)
Zero point
Segment 4 (decrease right Offset)
Segment 2 (increase right Offset)

Figure 9 Offset segments

The offset option will be released via the attributes "offset left" (0x00000400) and offset right (0x00000200) in the segment. The offset will be released via CAN bus in message 0x196 byte 5 bit 2 (switching right) and bit 3 (switching left). If this attribute is canceled while the vehicle still moves to the side, the vehicle stops with an error message. Therefore a free attribute should mark the end of the offset track early enough to undo the offset driving.

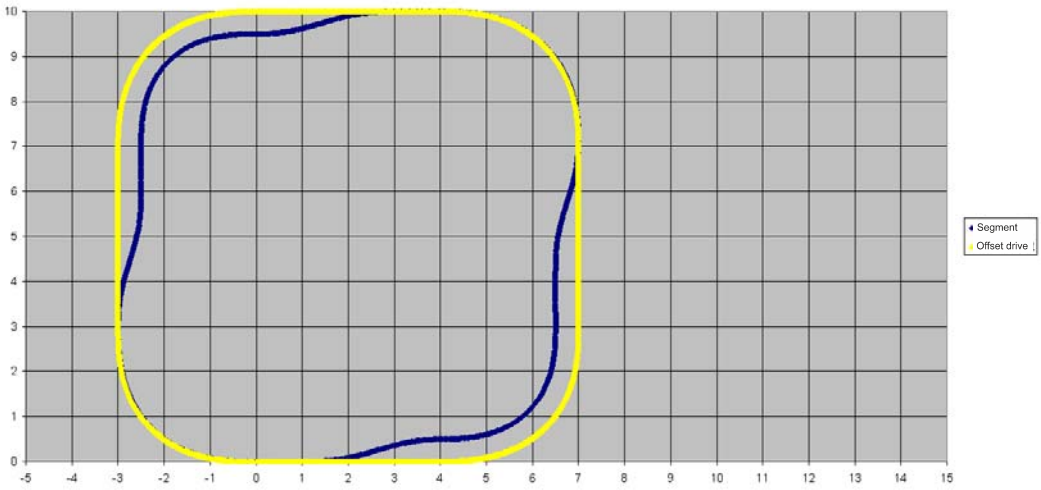


Figure 10 Example drive

2.1.4 Calculation of the Steering Angle

The key task of the steering controller is to keep the vehicle on the intended track. This means that the center of the fixed axis is constantly kept on the track, e.g. the center of the rear axis of a given three- wheeler as shown in Figure 11. This is realized with the steering angle. It is comprised of 2 components: The feed back control / regulator

and the feed forward control. If the steering controller is correctly set, 80% of the calculated steering angle results from the feed forward control (dependent on the driving conditions). Only the remaining percentage of 20% are provided by the feed back control / regulator.

2.1.4.1 Feed Forward Control

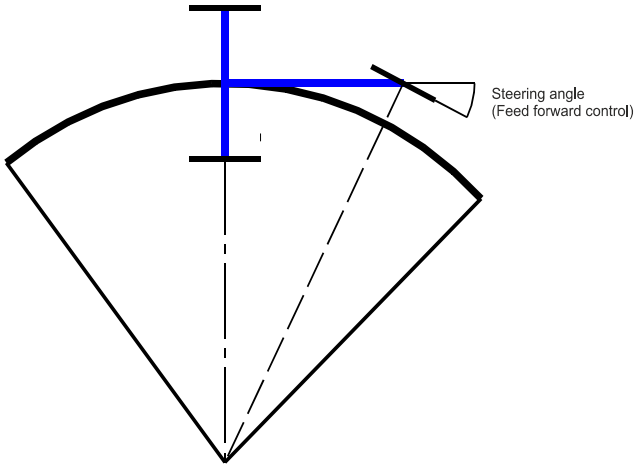


Figure 11 Feed forward control

The feed forward control calculates a steering angle that keeps the vehicle on the track. If the three-wheeler described is e.g. driven on a circle, the feed forward control calculates a steering angle, that adjusts the steered wheel tangentially towards the track. In an ideal situation the vehicle would exactly drive around this circle.

2.1.4.2 Feed Back Control

The feed back control steers the vehicle back to the intended course. At first the error in the vehicle position will be determined.

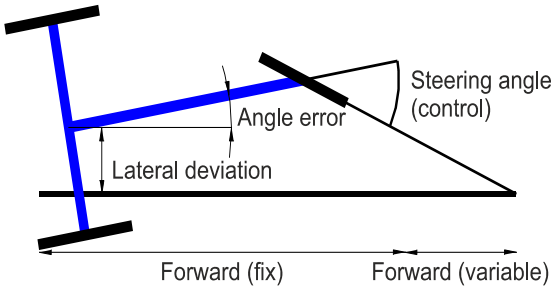


Figure 12 Feed back control

This error consists of two parts: The error of the angle and the lateral deviation.

The steering angle is calculated in such a way that the steering wheel points towards a point within the intended course in front of the vehicle. The distance between this point and the center of the rear axis consists of one fix and one variable (velocity dependent) component.

If the vehicle starts moving with this calculated steering angle, the point towards which the vehicle aims moves on. In this way the vehicle returns to its intended track without oscillating, provided the steering velocity is sufficiently fast and the vehicle speed adjusted.

To ensure a reduction of the oscillation for movements under worse conditions (higher velocities or slower steering) different parameters can be adjusted. Thus the angle at which the vehicle returns to the intended track can be limited dependent on the current velocity. For more detailed information see chapter 4 on page 28.

If the vehicle drives around a curve, the intended track for the controller is calculated by the tangent at the intersection of the rear axle. The needed angle to go around the curve is computed by an algorithm and added to the angle of the feed back control.

If the vehicle travels backwards, it is mirrored at the rear axis. Subsequently the steering angle of the mirrored front wheel is calculated and inverted.

2.1.5 Velocity Calculation

The velocity is obtained from the information of the support points. Here the velocity of the support point just passed and the upcoming support point is interpolated. Which of the two support point velocities ("velocity endpoint" or "velocity connection") is selected will depend on whether the vehicle shall stop at the segment's end or not. Once the direction of travel is reverted from forward to backward or vice versa, the "velocity endpoint" is selected. Also, if the course has a sharp bend at its end or terminates completely, the "velocity endpoint" is selected.

For some vehicles various additional protective mechanisms are integrated. If significant lateral deviations occur or if the difference between the set and actual steering angle is too large, the vehicle decelerates to 0,2m/s. It will only accelerate to the original velocity if the deviation was minimized.

If an error occurs or the vehicle drives beyond the end point, the velocity is set to 0.

2.1.6 Driving Modes

During normal operation of the vehicle, two different operation modes are used. The idle mode (see section Abschnitt 2.1.6.1) and the automatic mode (see section 2.1.6.3). In idle mode the vehicle can be operated by a driver or the segment search can be carried out. In the automatic mode, the steering controller controls the vehicle. The parameter test mode (see section 2.1.6.2) will only be accessed during commissioning.

NOTE! All other modes are applied in test carriers / prototypes or are applicable for demonstrations on exhibitions. They are not relevant for productive systems.

2.1.6.1 Idle Mode

This mode allows to operate the vehicle manually or the vehicle control unit can initiate a segment search.

2.1.6.2 Modus Parameter Test

This mode can only be activated if the vehicle is standing still. In this mode all basic functions can be tested during commissioning. For this purpose the terminal program provides a special menu where you can enter velocity and steering angle via the keyboard directly (see section 4.9 on page 40). Important characteristics including incremental data as well as actual velocity and steering angle will be displayed here.

2.1.6.3 Automatic Mode

In this mode the steering controller guides the vehicle. If the vehicle shall be operated manually (by a driver) you have to exit this mode. To access or quit this mode the user sends a request to the controller via the interface of the vehicle control unit, the keypad or the terminal program. It is possible to quit this mode at any time.

When requesting automatic mode, the vehicle has to fulfill the following conditions:

- the vehicle must be standing still
- the vehicle must be prepared for automatic mode
  - no vehicle errors are active
  - the determined position has to correspond to the given segment
- it must be possible to drive the given segment

2.1.7 Vehicle Options: Fork Lift Vehicle

The software of the steering controller offers various additional specifications for guided vehicles, such as triggering an emergency stop. The most common application is a fork lift vehicle (**stapler**). Further characteristics (maximum steering angle, maximum velocity, operation with a trailer or articulated steering) can be generated upon request. See our manual for a comprehensive list of pre-defined vehicle options.

2.2 The Internal Sensor Fusion

The internal sensor fusion calculates the position and the heading of the vehicle.

By using a short-term accurate odometric system (encoder) and the absolute transponder positioning sensor and / or Sky-Trax the advantages of both systems are combined. The odometric system is initialized through the absolute position sensor and outputs the vehicle position and vehicle heading everywhere along the track.

The inaccuracies accumulated within the system over time and distance are reset whenever an absolute position sensor (transponder) is available. Additionally the accuracies of both systems are compared and corrected proportionally.

In addition the sensor fusion outputs the velocity of the vehicle as well as the accuracy estimation of the respective position. The accuracy estimation is based on the accuracy table (see manual). The table is designed in such a manner that the inaccuracy immediately after crossing a transponder is small. That means errors grow faster related to the distance travelled since the angle is steadily worsening as well. Thus the accuracy coding declines accordingly with every meter travelled.

2.2.1 Odometric System

The odometric system determines the change in the vehicle position and vehicle heading using the wheel rotations and/or steering angle and/or gyro. There are different odometric systems available:

Number	Description	Advantages / Disadvantages
0	There are 2 monitored wheels on 1 fixed axle. Encoder 1 measures the rotations of the left wheel. Encoder 2 measures the rotations of the right wheel.	- Advantage: simple structure - Disadvantage: load dependent if the vehicle has airfillled rubber tires
1	There are 2 monitored wheels on 1 fixed axle. The alteration in heading angle is determined by the steering angle.	- Advantage: less load dependent - Disadvantage: inaccuracies in tight turns may occur
2	There are 2 monitored wheels on 1 fixed axle. The distance travelled by the vehicle is the average distance travelled by both wheels. The alteration in heading is determined by a gyro.	- Advantage: less load dependent - Disadvantage: additional gyro required
3	There are 2 monitored wheels on 1 steered axle. The alteration in heading angle is determined by the steering angle.	- Disadvantage: inaccuracies in tight turns may occur - Load dependent if the vehicle has airfilled rubber tires
4	There are 2 monitored wheels on 1 steered axle. The distance travelled by the vehicle is the average distance travelled by both wheels. The alteration in heading is measured by a gyro.	- Advantage: less load dependent - Disadvantage: additional gyro required

Table 4 List of the different odometric systems available, including advantages and disadvantages

All odometric systems have the advantage to be highly accurate over short distances and are prepared to supply the vehicle position and heading at any time. At start-up first of all the position must be initialized. The accuracy of odometry is affected over long distances and results in an accumulation of errors of the sensors and calculations. This may possibly cause considerable deviations.

Sensor failure detection is possible by comparing two different odometric systems.

Example

The position of a truck is determined by odometry 2 (*primary odometry*). Additionally odometry 0 will be calculated also (*secondary odometry*). Subsequently the measured values will be compared. The tolerances of the angle, as well as X and Y position can be parameterized. Odometry 0 will slightly differ in distance travelled from odometry 2 (the inaccuracy amounts to about 1% of the distance travelled). At the next transponder / Sky

Trax tag both odometries will be corrected and the difference between both is 0 again.
If the encoder is defective, odometry 0 calculates a distance. Odometry 2 measures a distance that is too short. Over a certain distance a considerable differentiation between both odometries exists (inaccuracy from 30% up to 50% of the distance travelled). Monitoring will be triggered accordingly and the vehicle stops.

2.3 Sensors for navigation

2.3.1 The Transponder Antenna

The transponder antenna outputs the position and the code of the transponder currently located underneath the antenna. The position lateral to the direction of travel has an accuracy of approximately 1 cm. The detection range is -250 mm up to +250 mm. Reading distance is approximately. 50 to 100 mm.

The position in direction of travel of the transponder is only transmitted when the center of the transponder antenna is crossing the transponder through the position impulse. When there is no transponder underneath the antenna, there is no output. It is only allowed to have 1 transponder at a time underneath the antenna. The parameters of the transponder antenna a set via an RS 232 interface which is described in the supplied antenna manual.

2.3.1.1 Transponder System for Positioning Calculation

NOTE! In order to calculate the position it is usually not sufficient to read only one single transponder.
Exception: the transponder can only be approached in one direction (e.g. transfer station).

The antenna is capable of outputting the position of the transponder with regards to the antenna, however the direction of the antenna with regards to the transponder cannot be determined. Thus two transponders have to be crossed to determine the position and angle of the vehicle. The odometry determines the track between these two transponders. The transponder list enables allocating absolute positions to the individually measured points (transponders). Thus it is necessary to read two transponders in order to determine the direction of the vehicle.

Depending on the degree of correlation between the measured distance and the positions of the transponders in the transponder list, the quality of the measurement can be estimated. The odometry is then corrected using the calculated position and the heading angle in relation to the measurement quality. If the quality of the measurement is not sufficient, the measurement will be ignored. The limits for the quality determination are partly definable or partly listed in the corresponding table of the reference manual.

It is the task of these tolerance definitions to protect a sufficient accuracy of the position against incorrect measurements. Thus over short distances only a measurement of high quality will be accepted. This prevents a positioning quality degradation caused by incorrect readings.

The limits defining a position as too inaccurate can partly be adjusted or are defined according to the tables in the reference manual. Those tables show that after 9 meters any measurement will be accepted. This ensures the continuation of the operation after a long distance drive without transponders and avoids a system shut down. The table shows practical, experience-based values.

2.3.1.2 Initialization of the Transponder Sensor Fusion

There are two options for the initialization of the transponder sensor fusion.

1. The vehicle reads the start transponder. The start transponder is a normal transponder which only has one possible direction to be crossed. This may be the case e.g. at a transfer station. The start transponder is marked accordingly and the start heading is recorded in 1/100°. A start transponder is only evaluated directly after the system has been switched on.
2. The vehicle crosses several transponders. After the first transponder a position cannot yet be calculated. After the second transponder the position and heading can be calculated. After the third transponder the position is confirmed and the accuracy is set to a good value provided the position of the third transponder corresponds to the position of the previous ones.

If the vehicle is steered by a driver (manual mode) it sometimes happens that the transponders are not crossed. This results in a decreasing accuracy of the odometry. As the system has not been switched off the only remaining possibility for initialization is number 2.

2.3.1.3 Transponder List

The transponder list is a CSV file (separated by a semicolon). It can be created and edited with Excel or other programs. The steering controller can import and export this list with the X-modem protocol using a terminal program. Additionally the list can be displayed from the steering controller with the terminal program.

```
1;1;-2480;-4555;9000;0;0;1
2;2;-2462;-3171;0;0;0;0
3;46;6000;0;0;0;0;0
4;4336;9500;0;0;0;0;0
5;8012;031;6891;9000;127;127;1
```

These values have the following meaning for the steering controller:

Number	Code	X Pos.	Y Pos.	Attribute 1	Attribute 2	Attribute 3	Attribute 4
1	1	-2480	-4555	9000	0	0	1
2	2	-2462	-3171	0	0	0	0
3	46	6000	0	0	0	0	0
4	4336	9500	0	0	0	0	0
5	8012	3031	6891	9000	127	127	1

Table 5 Explanation transponder list

The first column displays the serial numbers of the transponder tags. The second column includes the transponder or Sky-Trax codes. The following two columns stand for the position in X or Y direction. In the fifth column the heading of the start transponder is recorded in 1/100°. For Sky-Trax tags attribute 1 and 2 display the tag size in mm.

Due to size difference of the tags as well as differences in the height of the mounting points deviations may occur. The correct value is derived from commissioning (see chapter 4 on page 28).

2.3.2 Sky-Trax

This system is based on an image processing technology, usually using an upward directed camera. The camera on the vehicle is positioned in such a way that it is able to read the two-dimensional tags under the ceiling. Theses readings are transmitted back and the relative position and rotational orientation will be supplied. Additionally the tag code will be transmitted. If there is no tag in the camera's coverage area no position will be transmitted. There may be several tags in the camera's detection range.

As the Sky-Trax camera has only one ethernet-interface, its output must be converted by the WLAN radio modem G 76431 via RS 232 (ethernet interface of the HG 61430 is not yet available). The WLAN radio modem offers the additional advantage that the images captured by the camera can also be displayed on a stationary controller. This facilitates an easy parameterization of the camera.

One disadvantage of the Sky-Trax System is the great distance between the tag and the camera. The further away the tag is from the camera, the greater is the detection range and area coverage of the camera. However uneven surfaces or a fully suspended vehicle have a negative effect. A position error caused by vehicle inclination depends on the degree of tilt and the distance to the tag.

2.4 Vehicle Control Unit

The track guidance controller communicates with the vehicle control unit via CAN Bus, Profibus or Ethernet. The vehicle control unit adapts the steering controller to the vehicle. This offers the advantage of a standard interface. The customer can directly affect the adaptation and is therefore able to make the necessary adjustments. Vehicle control unit and steering controller may mutually monitor their communication. This guarantees a higher level of security. The vehicle control unit is responsible for control-

ling vehicle components such as motor controller, brake, speed and steering. In some cases a steering servo (e.g. *Berger Lahr*) or a motor control can be directly controlled by the vehicle control unit.

In addition to the serial interfaces 4 IO channels are available. The configuration depends on the set vehicle option. For most vehicle options IO1 is the input from the position impulse of the transponder antenna. IO4 is the output for emergency stop. The number of in- and outputs can be increased by an optional IO extension by IFM (see section 1.3.1 on page 6).

3 Interfaces

The steering controller has several interface options providing data transmission. These include 2 CAN, 1 Profibus, 1 Ethernet and 4 serial RS232 interfaces. Additionally the optional internal radio modem can be accessed via an integrated interface. This chapter provides an overview of the different interfaces. In the annex of the reference manual you will find a tabular listing of the data actually transferred.

NOTE! You will find the hardware description of the interfaces in the provided user manual for control unit HG 61430.

3.1 CAN Bus

Detailed specifications of the CAN messages are described in the reference manual.

3.1.1 CAN 1

Interface 1 is responsible for the communication of general functions of the steering controller. These are:

- status information of the steering controller
- steering angle, nominal velocity etc.
- position output of internal sensor fusion
- communication with vehicle control unit (segments, status of vehicle, etc.)
- communication with transponder antenna
- communication with gyro
- communication with IO extension

3.1.2 CAN 2

Interface 2 is responsible for the communication of the additional functions of the steering controller. These include:

- communication with the laser scanner
- communication with the steering servo
- communication with the angle sensor (for backward movement of the trailer)
- communication with guide wire antenna **HG 73350**
- communication with evaluation unit for 2 cameras **HG 738840**
- command box of the gyro
- remote control of the basic features with CAN Bus

3.2 Profibus

The device works as a slave with profibus-DP V0 according to DIN E 19245 T3. The interface offers an automatic baud rate detection. The profibus address may be adjusted. You will find detailed specifications accordingly in the reference manual.

3.3 Ethernet

The ethernet interface operates at 10 Mbit/s. For further specifications please see the reference manual.

3.4 Serial Interfaces

You will find detailed specifications of the serial interfaces in the reference manual.

3.4.1 SIO 1

SIO1 is connected to the optional internal narrow band radio modem.

3.4.2 SIO 2

SIO2 is a RS 232 interface with a predefined baud rate 8 bit, no parity and 1 stop bit. The following protocols can be configured via parameters:

Name	Description
Camera	Connection of a PC for performing edge detection with a PMD camera (company internal use)
Remote control	Remote control protocol of the basic functions via the narrow band radio modem
SICK scanner	Reads angles and distances from a SICK scanner (company internal use)

Table 6 SIO 2 protocols

3.4.3 SIO 3

SIO3 is an adjustable RS 232 interface with the following default values: baud rate 8 bit, no parity and 1 stop bit. The following protocols can be selected with parameters:

Name	Description
Laser scanner	Connection of a laser scanner **HG 43600XA** (can also be connected via CAN Bus)
Sky-Trax	Connection of a Sky Trax camera
SICK position	Connection of a PC calculating position and steering angle with a SICK scanner (company internal use)

Table 7 SIO 3 protocols

3.4.4 SIO 4

SIO4 is an adjustable RS 232 interface with the following default values: baud rate 8 bit, no parity and 1 stop bit. The following protocols can be configured via parameters:

Name	Description
Convoi Leader	Telegram of the leading vehicle (electronic tow-bar, company internal use)
Convoi Chaser	Telegram of the following vehicle (electronic tow-bar, company internal use)
Ballett protocol	Connection of a PC ensuring collision free operation of 4 vehicles (company internal use)

Table 8 SIO 4 protocols

3.5 Terminal

Terminal is an adjustable RS 232 interface with the following default values: baud rate 8 bit, no parity and 1 stop bit. The terminal emulation is ANSI. It offers communication via a connected PC/laptop, e.g. for commissioning. The following functions are possible:

- display of the current data
- display of the commissioning menu, which allows monitoring and controlling all basic vehicle functions via keys
- recording of the current data in order to prepare them for import into Excel
- import, export and editing of parameters
- import, export and editing of segments
- import, export and display of transponders / Sky-Trax tags

3.6 IO 1 to 4

The configuration depends on the pre-set vehicle options. In most cases IO1 is used as the position impulse input from the transponder antenna and IO4 is the output for emergency stop. The exact allocation is shown in the corresponding tables in the reference manual.

4 Commissioning

For hardware mounting please see our included hardware description for control unit **HG 61430**.

CAUTION! When starting the commissioning of the vehicle **ensure that all safety devices are installed and functional**!

NOTE! At the beginning of commissioning, the vehicle has to be lifted up from the ground!

If the vehicle has a vehicle control unit (recommended) part of the commissioning tasks can be fulfilled without the vehicle itself. This primarily affects the communication between the steering controller and the vehicle control unit.

4.1 Commissioning of Communication

Internal system communication between the components is normally done via CAN bus. Therefore it is recommended to use a corresponding CAN adapter and a CAN display program, for example *Peak CAN Bus Adapter* and *PCAN Explorer*.

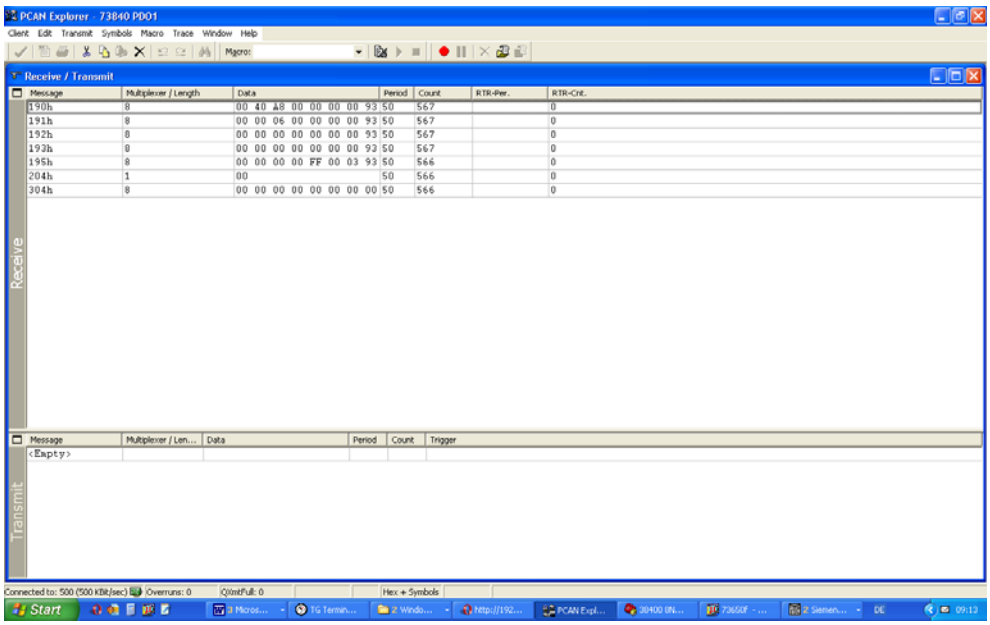

PCAN Explorer - 73840 PDO1
Client Edit Transmit Symbols Macro Trace Window Help
Receive / Transmit
Message Multiplexer / Length Data Period Count RTR-Per. RTR-Cnt.
190h 8 00 40 A8 00 00 00 00 93 50 567 0
191h 8 00 00 06 00 00 00 00 93 50 567 0
192h 8 00 00 00 00 00 00 00 93 50 567 0
193h 8 00 00 00 00 00 00 00 93 50 567 0
195h 8 00 00 00 00 FF 00 03 93 50 566 0
204h 1 00 50 566 0
304h 8 00 00 00 00 00 00 00 00 50 566 0
Receive
Message Multiplexer / Len... Data Period Count Trigger
<Empty>
Transmit
Start

Figure 13 PCAN explorer displaying messages of the steering controller

When switched off the resistance of the CAN bus has to be measured. The CAN bus must be terminated with 60 ohm all together (either 120 ohm each end of a line network or 60 ohm centrally of a star network). Only if this can be assured it is possible to start up the guidance controller and test the basic communication via CAN bus with the PCAN explorer. Subsequently further commissioning should be implemented using a PC / laptop and the corresponding terminal program.

4.2 Commissioning Terminal Program

For further commissioning purposes use the operating software running on the steering controller. The software can be called up via the RS 232 interface and a connected PC running a terminal program.

Below we refer to the **HyperTerminal®** (`Hypertrm.exe`)Program, which is included in Microsoft Windows. It is also possible to use any other terminal program capable of ANSI emulation. Should you use another software please see our manual provided and adjust the values described in section 4.2.2 Please continue on page 30.

4.2.1 Finding Hyper Terminal / Adding Hyper Terminal to the system

First make sure that the Hyper Terminal software is installed on your system. This is important, as it is not necessarily part of the Windows default installation. If it is not installed it can be easily added later on. Therefore the original Microsoft operating system installation CD is required. The installation process is as follows:

1. Open the system control (in the picture Windows 95).

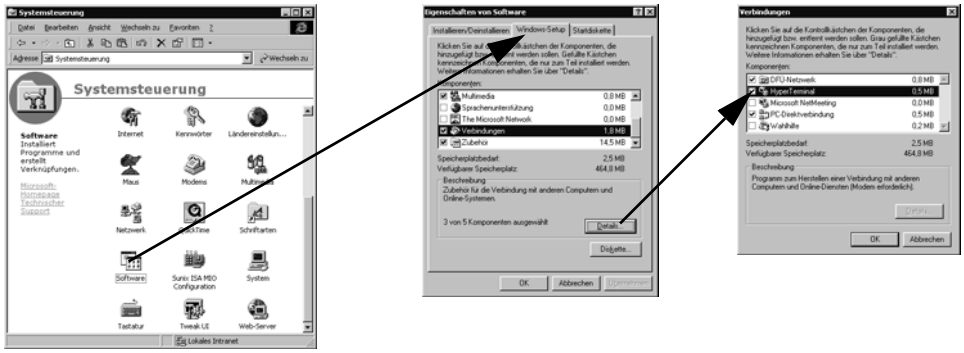


Figure 14 Add Hyper Terminal to the System

2. Select Icon Software. Select the tab Windows set-up. Select submenu Connections. Click Details... .
3. Check whether there is a checkmark in front of (yes = ☑; no = ☐). If yes the program is installed on your system, then cancel these two dialogs and move to the next step. Otherwise add the checkmark and close both windows with OK.
4. Subsequently you will be asked to insert the Windows installation CD in the CD drive. Then confirm the following messages with OK. HyperTerminal will be installed and is available for operation.

4.2.2 Parameter Settings

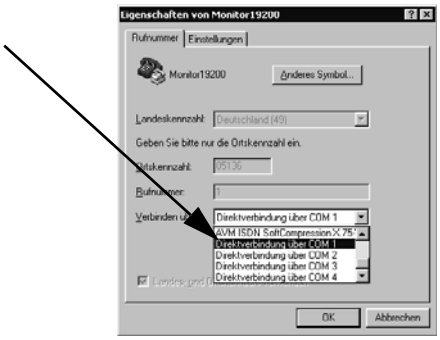
The following parameter settings are required. Adapt the COM-Port, if necessary (see below):

Terminal Settings Monitor Program	
Baud rate	115200 Baud Also possible: 9600, 19200, 38400 und 57600 Baud
Terminal emulation	ANSI
Terminal	24 lines, 80 columns
Parity	None
Datenbits	8
Stop bits	1
Flow control	None
PC interface (port)	COM1 (may differ in cases, see below)

Table 9 Terminal settings for the monitor program

If you use another port than COM1 with Hyper Terminal, change the port in the following way:

1. In the file menu select menu item properties (or click on the corresponding icon). The window shown to te right opens.
2. Choose the corresponding port from the submenu connect and confirm with OK. Save the modified values, if an appropriate message appears when quitting Hyper Terminal.



4.3 Using the Terminal Program

Starten Sie HyperTerminal auf dem PC und verbinden Sie den entspre-
Start Hyper Terminal on your PC and connect the corresponding COM port to the connector "Terminal" on the control unit HG 61430.

Switch on control unit HG 64130 and wait until the last message from the operating system is visible. Subsequently fill in code `314159` and confirm with Enter abgeschlossen werden. The following menu will be displayed:

4.4 Main Menu

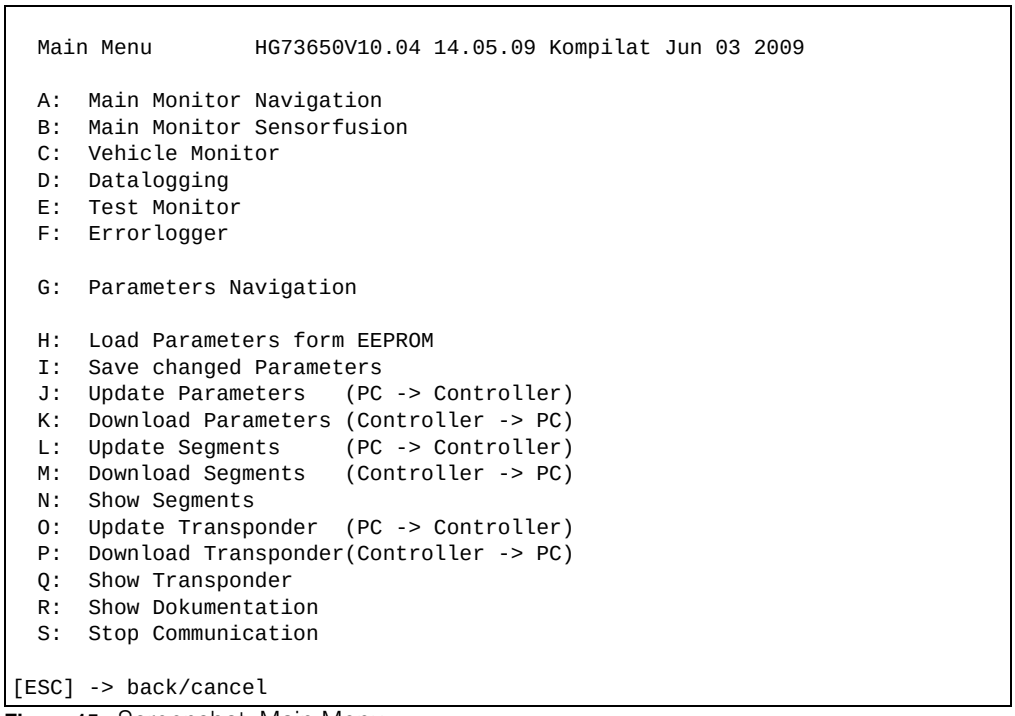

Main Menu HG73650V10.04 14.05.09 Kompilat Jun 03 2009
A: Main Monitor Navigation
B: Main Monitor Sensorfusion
C: Vehicle Monitor
D: Datalogging
E: Test Monitor
F: Errorlogger
G: Parameters Navigation
H: Load Parameters form EEPROM
I: Save changed Parameters
J: Update Parameters (PC -> Controller)
K: Download Parameters (Controller -> PC)
L: Update Segments (PC -> Controller)
M: Download Segments (Controller -> PC)
N: Show Segments
O: Update Transponder (PC -> Controller)
P: Download Transponder(Controller -> PC)
Q: Show Transponder
R: Show Dokumentation
S: Stop Communication
[ESC] -> back/cancel

Figure 15 Screenshot: Main Menu

From this menu you are able to access all other menus. Applying the characters on the left you can branch off into the corresponding submenus. Leave the submenus using the Esc key. The main menu is divided into three sections. The top area from A to F is used for the display or recording of data. In this field a simple manual vehicle controller (E) is integrated as well.

The middle section has only one menu item. With G you are able to branch off to all further parameter menus.

The lower section of the menus is for saving and loading the parameters. Here it is possible to transmit data from / to HG 61430. Users also have the option to view the data.

4.5 (A) Main Monitor Navigation

Once [A] has been selected in the main menu, the following display appears.

```
Main Monitor Navigation

Vehicle:                    Target:                     Deviation:
Angle:        0.00 [ ° ]    Angle:        0.00 [ ° ]    Angle:      0.00 [ ° ]
Pos X:        0.00 [ m ]    Pos X:        0.00 [ m ]    Diag.:      0.00 [ m ]
Pos Y:        0.00 [ m ]    Pos Y:        0.00 [ m ]    Axis :           [ m ]
Speed:        0.00 [m/s]    Speed:        0.00 [m/s]    Speed:      0.00 [m/s]
Steer:        0.00 [ ° ]    Steer:        0.00 [ ° ]    Steer:      0.00 [ ° ]
                                                        Front:      0.00 [ m ]
Segment:                    Error:                      Rear :      0.00 [ m ]
Number1: 255 /   4 [R/T]    Vehicle  :      40          Accur:    100.00 [ m ]
Number2: 255 / 255 [R/T]    Condition:      A8
Number3: 255 / 255 [R/T]    Request  :       0
Point  :         0 [Nr.]
Sample :      0.00 [   ]    Steering:
Attrib.:         0          Deviation:    0.00 [ ° ]
Status :     Start          Curvature:    0.00 [ ° ]

Status:                     Clearance:       1
Timer :       Wait          Modus:           Idle Mode
Main  :       Wait
```

Figure 16 Screenshot: Main Monitor Navigation

4.5.1 Monitor Outputs

Parameters "Vehicle" display the current vehicle values:

Name	Description	Unit
Angle	Actual vehicle heading	degrees
Pos X	X component of position of the symmetrical axis of the vehicle	meters
Pos Y	Y component of position of the symmetrical axis of the vehicle	meters
Speed	Current speed of vehicle	meters / second
Steer	Current steering angle of vehicle	degrees

Table 10 Main Monitor Navigation: Section "Vehicle"

Parameters "Target" summarize the nominal values of the current segment.

Name	Description	Unit
Angle	nominal vehicle heading	degrees
Pos X	Set value for X component of position of the symmetrical axis of the vehicle	meters
Pos Y	Set value for Y component of position of the symmetrical axis of the vehicle	meters
Speed	Nominal value for speed of the vehicle	meters / second
Steer	nominal value for steering angle of vehicle	degrees

Table 11 Main Monitor Navigation: Section "Target"

Parameters "Deviation" displays the difference between actual und nominal values.

Name	Description	Unit
Angle	Deviation of the heading of the vehicle	degrees
Diag.	Lateral displacement of the vehicle	meters
Axis	Longitudinal deviation of the vehicle	meters
Speed	Error in velocity	meters / second
Steer	Error in steering angle	degrees
Front	Deviation of the front axle of the vehicle	meters
Rear	Deviation of the rear axle of the vehicle	meters
Accuracy	Estimated position error	meters

Table 12 Main Monitor Navigation: Section "Deviation"

Parameters "Segment" summarize all data related to segments.

Name	Description
Number1	Segment received from / sent to the vehicle control unit. It is the most current segment.
Number2	Segment received from / sent to the vehicle control unit. It is the segment following next.
Number3	Segment received from / sent to vehicle control unit. It is the segment following the next segment.
Point	Number of the last crossed support point on the current segment

Table 13 Main Monitor Navigation: Section "Segment" (part 1 of 2)

Name	Description
Sample	Position between the support points. When starting a segment, sample is set to 1, raises up to 3 and is reset to 2 when reaching the third support point of the same segment (the next support points are used for the reconstruction of the track). Once the segment has been finished, the value rises above 3 as there are no more support points available.
Attrib.	The current attribute is displayed in hexadecimal format. The 16 lower bits are pre-used internal bits, 16 upper bits are freely programmable; see section 2.1.2 on page 15.
Status	As long as the vehicle is still in front of the second support point of the segment "Start" is displayed. Between point 2 and 3 the status is "Start+1". Between the last point and the second last point the status is "End-1". Once the last point has been crossed the status is "End". For all other sections the status is "middle".

Table 13 Main Monitor Navigation: Section "Segment" (part 2 of 2)

Parameters "Error" summarize the different errors that might occur.

Name	Description
Vehicle	Bit coded vehicle error (see reference manual)
Condition	Error of automatic mode (see reference manual)
Request	Error when requesting automatic mode (see reference manual)

Table 14 Main Monitor Navigation: Section "Error"

Parameters "Steering" summarize the components of the steering angle.

Name	Description
Deviation	Part of the steering angle that is generated from the deviation of the nominal position.
Curvature	Part of the steering angle that is generated from the curvature of the target course.

Table 15 Main Monitor Navigation: Section "Steering"

Parameters "Status" indicate the status of the steering controller.

Name	Description
Timer	Status of the navigation (50 ms timer that is running the navigation)
Main	Status of the main program (interface user)

Table 16 Main Monitor Navigation: Section "Status"

In case "Clearance" is set to 1, the vehicle control unit can operate the steering controller. If there are any manual entries via the terminal software, this clearance will be cancelled. Then the steering controller only reacts to inputs from the terminal software.

4.5.2 Input Options

Key	Desription
ESC	Branch to the Main Menu
1	Set segment 1 manually (current segment)
2	Set segment 2 manually (next segment)
3	Set segment 3 manually (after next segment)
A	Set automatic mode manually
Space bar	Terminate automatic mode
F	Set release for control unit
G	Toggle release for manually set automatic mode
J	Drive left offset
I	Drive no offset
L	Drive right offset
K	Switch on convoy mode (if available for the used vehicle model)
C	Toggle release of central control unit
R	Reset of default values for vehicle during vehicle simulation

Table 17 Main Monitor Navigation: Input options

4.6 (B) Main Monitor Sensorfusion

```
  Main Monitor Sensorfusion


  Antenna1:                 Antenna2:                 Odometrie:
  Status :         0 [   ]  Status :         0 [   ]  Status :         0 [   ]
  Code   :         0 [   ]  Code   :         0 [   ]  Angle  :      0.00 [ ° ]
  Delta Y:     0.000 [ m ]  Delta Y:     0.000 [ m ]  Pos X  :      0.00 [ m ]
  Sum Vo.:         0 [   ]  Sum Vo.:         0 [   ]  Pos Y  :      0.00 [ m ]
  Current:         0 [   ]  Current:         0 [   ]  Speed  :      0.00 [m/s]
  Reading:         0 [   ]  Reading:         0 [   ]  Accur. :    100.00 [ m ]
  Pos. W :     0.000 [ m ]  Pos. W :         0 [ m ]
  Pos. Y :     0.000 [ m ]  Pos. Y :         0 [ m ]  Sky Trax:
                                                      MC1/MC2:         0;     0
  Odometrie1:               Odometrie2:               MW1/MW2:         0;     0
  Angle S:       0.00 [ ° ] Angle D:       0.00 [ ° ] Counter:         0;     0
  Dev.X S:       0.00 [ m ] Dev.X D:       0.00 [ m ] Abstand:      0.00;  0.00
  Dev.Y S:       0.00 [ m ] Dev.Y D:       0.00 [ m ] Winkel :      0.00
  Dist.  :       0.00 [ m ] Dist.  :       0.00 [ m ] Pos    :      0.00;  0.00


  Deviation Single:         Deviation Double:         Gyro:
  Angle S:       0.00 [ ° ] Angle D:       0.00 [ ° ] Angle  :      0.00 [ ° ]
  Dev.X S:       0.00 [ m ] Dev.X D:       0.00 [ m ] Offset :      0.00 [ ° ]
  Dev.Y S:       0.00 [ m ] Dev.Y D:       0.00 [ m ] Move   :         0 [   ]



[ESC] -> back/cancel
```

Figure 17 Screenshot: Main Monitor Sensorfusion

"Antenna 1" defines the status of antenna 1.

Name	Description	Unit
Status	Bit coded antenna status (see reference manual)	
Code	Read transponder code	
Delta Y	Position of the transponder underneath the antenna in Y direction	
Sum Vo.	Signal strength of the transponder (a measure for transponder signal strength, has to be > 400)	
Current	Current consumption of the transmitter	
Reading	Number of transponder readings	
Pos. X	X position of transponder taken from the transponder list	meters
Pos. Y	Y position of transponder taken from the transponder list	meters

Table 18 Main Monitor Sensorfusion: Section antenna 1

"Antenna 2" defines the status of antenna 2.

Name	Description	Unit
Status	Bit coded antenna status (see reference manual)	
Code	Read transponder code	
Delta Y	Position of the transponder underneath the antenna in Y direction	
Sum Vo.	Signal strengthof the transponder (a measure for Transponder signal strength, has to be > 400)	
Current	Current consumption of the transmitter	
Reading	Number of transponder teadings	
Pos. X	X position of transponder taken from the transponder list	meters
Pos. Y	Y position of transponder taken from the transponder list	meters

Table 19 Main Monitor Sensorfusion: Section antenna 2

"Odometry" defines the status of the odometric system.

Name	Description	Unit
Status	Output status byte (see reference manual)	
Angle	Heading of the vehicle (mathematically positive)	degrees
Pos X	X position of the vehicle	meters

Table 20 Main Monitor Sensorfusion: Section odometry (part 1 of 2)

Name	Description	Unit
Pos Y	Y position of the vehicle	meters
Speed	Velocity of the vehicle	meters / second
Accur.	Number of transponder readings	

Table 20 Main Monitor Sensorfusion: Section odometry (part 2 of 2)

"Odometrie1" defines the status of the odometric system of antenna 1.

Name	Description	Unit
Angle	Heading of the vehicle relative to the last transponder crossed by antenna 1	degrees
Pos X	X Position of the vehicle relative to the last transponder crossed by antenna 1	meters
Pos Y	Y Position of the vehicle relative to the last transponder crossed by antenna 1	meters
Dist.	Distance traveled since capturing the last transponder	meters

Table 21 Main Monitor Sensorfusion: Section odometry 1

"Odometrie2" defines the status of the odometric system of antenna 2.

Name	Description	Unit
Angle	Heading of the vehicle relative to the last transponder crossed by antenna 2	degrees
Pos X	X Position of the vehicle relative to the last transponder crossed by antenna 2	meters
Pos Y	Y Position of the vehicle relative to the last Transponder crossed by antenna 2	meters
Dist.	Distance traveled since capturing the last transponder	meters

Table 22 Main Monitor Sensorfusion: Section odometry 2

"Sky Trax" defines the status of the Sky-Trax System.

Name	Description		Unit
MC1/MC2	Left	Tag code of the first tag	[ ]
	Rigth	Tag code of the second tag	

Table 23 Main Monitor Sensorfusion: Section Sky-Trax (part 1 of 2)

Name	Description		Unit
MW1/MW2	Left	Tag angle of the first tag	[°]
	Right	Tag angle of the second Tag	
Counter	Left	Counts all characters received from Sky-Trax	[ ]
	Right	Counter of all calculated positions	
Distance	Left	Measured distance of both tags	[meters]
	Right	Theoretical distance of both tags	
Angle	Calculated steering angle of the Sky-Trax System		[ ]
Pos	Left	Calculated X Position of the Sky-Trax System	[meters]
	Right	Calculated Y Position of the Sky-Trax System	

Table 23 Main Monitor Sensorfusion: Section Sky-Trax (part 2 of 2)

"Deviation Single" summarizes the deviations of the single measurements. For a single measurement, 1 antenna, 2 transponders and the distance traveled between these two transponders are required.

Name	Description	Unit
Angle S	Deviation between the previous heading angle of the vehicle and the last single measurement	degrees
Dev.X S	Deviation between the previous vehicle position in X direction and the last single measurement	meters
Dev.Y S	Deviation between the previous vehicle position in Y direction and the last single measurement	meters

Table 24 Main Monitor Sensorfusion: Section "Deviation Single"

"Deviation Double" summarizes the deviations of the double measurements. For a double measurement, 2 antenna, 2 transponders and the distance traveled between these two transponders are required.

Name	Description	Unit
Angle D	Deviation between the previous heading angle of the vehicle and the last double measurement	degrees
Dev.X D	Deviation between the previous vehicle position in X direction and the last double measurement	meters
Dev.Y D	Deviation between the previous vehicle position in X direction and the last double measurement	meters

Table 25 Main Monitor Sensorfusion: Section "Deviation Double"

Unter `Gyro` sind die wichtigsten Werte des Gyro zusammengefasst.

Name	Description	Unit
Angle	Angle of the gyro without drift correction and angle offset	degrees
Offset	Offset for correction of drift while standing	degrees
Move	Status is 1 if the vehicle is moving	

Table 26 Main Monitor Sensorfusion: Section "Gyro"

4.7 (C) Vehicle Monitor

The Vehicle Monitor is an output designed for all vehicle options. The output for each specific vehicle option is shown in the reference manual.

4.8 (D) Datalogging

For trouble shooting during commissioning or operation the steering controller offers two options - data logging, as described below and error logging, described in section 4.10 on page 42.

The best and more flexible solution is data logging. Using this option a laptop has to be connected during operation. It will log data applying the terminal program. Which data is logged can be selected in the corresponding parameter menu. As the selection of output values depends on the parameters, these values are described in chapter 4.11.9 „(I) Datalogging (Parameterization of the output)“. For the process of data logging first press button D in the main menu. Subsequently the following window will be displayed:

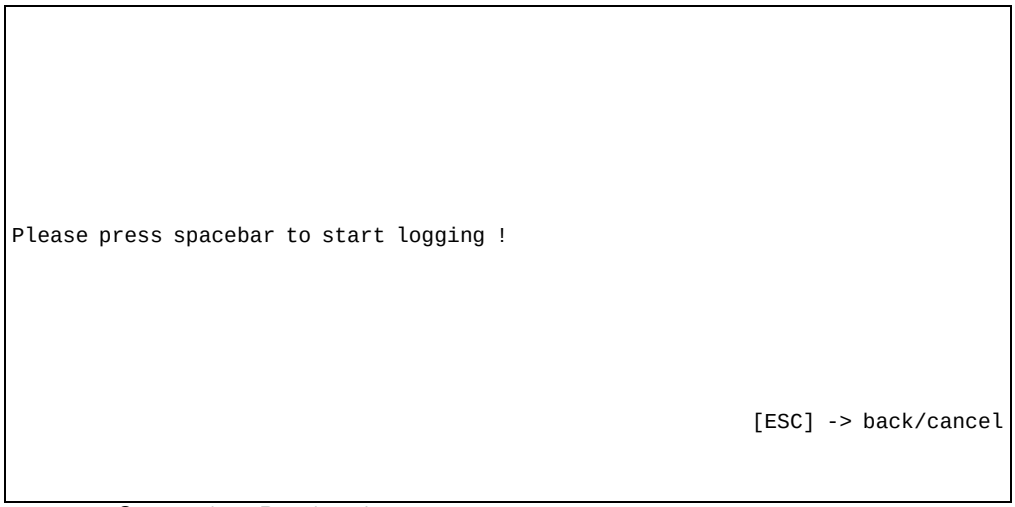


Figure 18 Screenshot: Datalogging

Then select `Hyperterminal` -> `Transfer` -> `Capture Text`, afterwards name the file and start recording with Hyper Terminal.

ATTENTION! Only then you should press the space bar! A correct sequence of these steps is essential. Otherwise the heading of data recording and the related allocation of these data would be lost.

When quitting the data logging, first terminate the capture by following the sequence `Hyperterm` -> `Transfer` -> `Capture Text` -> `Stop`. Then exit the submenu by pressing Esc.

4.9 (E) Test Monitor

The test monitor enables controlling the values output by the Steering Controller via keys. This is especially useful during commissioning, in order to test the interfaces and functions of the vehicle.

```
  Parameter Test

  Position:              Odometric System:            [   ]
  Angle:         0.00    Inkrements left :          0 [   ]
  Pos X:         0.00    Inkrements right:          0 [   ]
  Pos Y:         0.00    Gyro            :     0.0000 [ - ]


               Aktual    Target    unit    Possible Action
  Steering:      0.00      0.00   [ ° ]    Left  : A    Right : D
  Speed   :      0.00      0.00   [m/s]    Faster: W    Slower: S
                                           More  : X    Less  : Y
                                           Stopp : Space
                                           Forwa.: F    Neutr.: N    Rew.: R
                Speed                      More  : O    Less  : L
  Output  :      0.00
  P       :      0.00
  I       :      0.00
  D       :      0.00
  Ramp    :      0.00
  Poti    :       127
  Breakes :         0


[ESC] -> back/cancel
```

Figure 19 Screenshot: Test Monitor

4.9.1 Display outputs

"Position" indicates the position of the vehicle.

Name	Description	Unit
Angle	Heading of the vehicle (mathematically positive)	degrees
Pos X	X Position of the vehicle	meters
Pos Y	Y Position of the vehicle	meters

Table 27 Test Monitor: Section "Position"

"Odometric System" outputs the sensor data for the odometry.

Name	Description	Unit
Inkrements left	Increments of the left wheel	
Inkrements right	Increments of the right wheel	
Gyro	Angle of the gyro without offsets	degrees

Table 28 Test Monitor: Section "Odometric System"

Additionally nominal and actual steering angle as well as nominal and actual velocity are displayed.

Name	Description	Unit
Steering/Aktual	Actual steering angle	degrees
Steering/Target	Nominal steering angle	degrees
Speed / Aktual	Actual velocity	meters / second
Speed / Target	Nominal velocity	meters / second
Output	Output of the velocity regulator *)	
P	P- Portion of the velocity regulator *)	
I	I- Portion of the velocity regulator *)	
D	D- Portion of the velocity regulator *)	
Rampe	Acceleration ramp *)	
Poti	Control of the digital potentiometer *)	
*) if available in the selected vehicle option		

Table 29 Test Monitor: Section actual and nominal steering angle

4.9.2 Input Options

Key	Description	Unit
ESC	Return to the main menu	
a	Nominal steering angle - 0,5	degrees
A	Nominal steering angle - 2	degrees
b	Nominal steering angle - 0,5	degrees
B	Nominal steering angle+ 2	degrees
w	Nominal velocity +0,1	meters / second

Table 30 Test Monitor: Input Options (part 1 of 2)

Key	Description	Unit
W	Nominal velocity +0,5	meters / second
s	Nominal velocity -0,1	meters / second
S	Nominal velocity - 0,5	meters / second
Space bar	Nominal velocity = 0	meters / second
+	Increase brake (if available in the selected vehicle model)	
-	Decrease brake (if available in the selected vehicle model)	

Table 30 Test Monitor: Input Options (part 2 of 2)

4.10 (F) Error Logger

In order to identify errors during commissioning or operation the steering controller offers two options. The first priority is the more universal data logging, described in section 4.8 on page 39, secondly we have the error logger, described below.

In order to run the error logger **it is not necessary** to connect a PC / laptop during operation. In case of error it is sufficient to connect the PC / laptop subsequently, as the data remains stored inside the steering controller until it is switched off. The PC / laptop can retrieve the required data via a terminal software. However, always the same variables will be recorded (see Table 31 on page 43) at the time of a transponder position impulse. This limits the possibility of troubleshooting for positioning and it only works together with a transponder system.

To record data button F for Error logger in the main menu has to be pressed first. Then the following window will open.

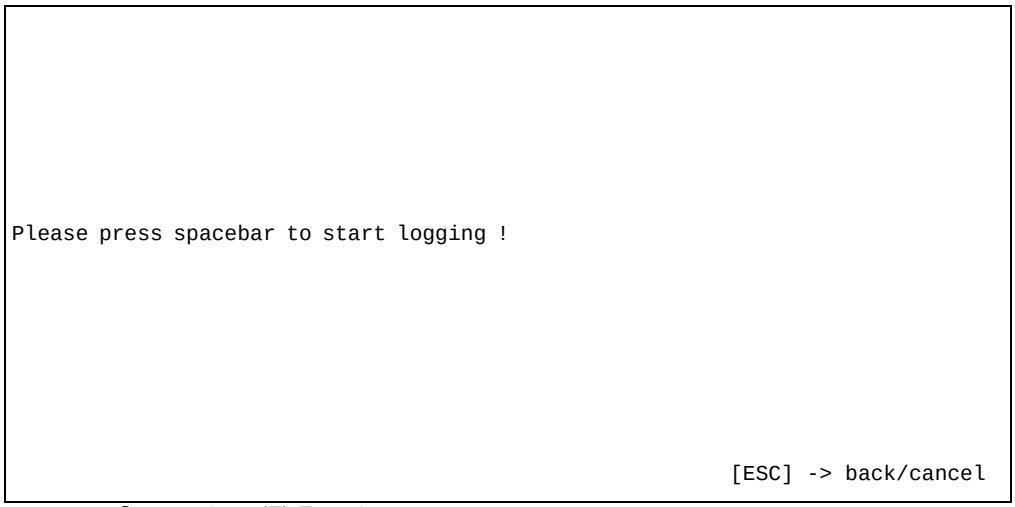


Figure 20 Screenshot: (F) Error Logger

Then select `Hyperterminal` -> `Transfer` -> `Capture Text`, afterwards name the file and start recording with Hyper Terminal.

ATTENTION! Only then you should press the space bar! A correct sequence of these steps is essential. Otherwise the heading of data recording and the related allocation of these data would be lost.

When quitting the data logging, first terminate the capture by following the sequence `Hyperterm` -> `Transfer` -> `Capture Text` -> `Stop`. Then exit the submenu by pressing Esc. The generated CSV- file has the structure in the table below. The columns will be displayed when loading the CSV- file into a spreadsheet application such as Excel.

Column	Name	Description
A	Odo.dW_Neu	Actual steering angle [°] based on odometry
B	Odo.dX_Neu	Actual position, X component [m] based on odometry
C	Odo.dY_Neu	Actual position, Y component [m] based on odometry
D	t_x_1	Transponder position underneath antenna 1 in X direction [m]. This position will be loaded via the code taken from the transponder table.
E	t_y_1	Transponder position underneath antenna 1 in Y direction [m]. This position will be loaded via the code taken from the transponder table.
F	t_x_2	Transponder position beneath antenna 2 in X direction [m]. This position will be loaded via the code taken from the transponder table.
G	t_y_2	Transponder position beneath antenna 2 in Y direction [m]. This position will be loaded via the code taken from the transponder table.
H	t_dy_1	Lateral displacement of transponder position beneath antenna 1 [m]
I	t_code_1	Transponder code read by antenna 1
J	t_status_1	Status of transponder antenna 1
K	t_dy_2	Lateral displacement of transponder position beneath antenna 2 [m]
L	t_code_2	Transponder code read by antenna 2
M	t_status_2	Status of transponder antenna 2
N	Lenkwinkel	Actual steering angle [°]

Table 31 Errorlogger: Vehicle Status (part 1 of 7)

Column	Name	Description
O	M_auswertung	Bitcoded; indicates the type of the latest calculation 0 x 10 individual evaluation antenna 1 0 x 20 individual evaluation antenna 2 0 x 40 double evaluation of antenna 1 0 x 80 double evaluation of antenna 2
P	Schlechter_Transponder	Latest transponder code where the odometry- based distance measurement between two transponders does not comply with the distance entries in the transponder table.
Q	Winkel_Fzg	Actual vehicle heading [°]
R	Pos_X_Fzg	Actual position, X component [m]
S	Pos_Y_Fzg	Actual position, Y component [m]
T	Transponderabstand	Distance between the current transponder and the previously read transponder taken from the transponder table [m]
U	Odometrieabstand	Distance of the current transponder to the previously read transponder based on odometry
V	faktor_M	Odometry and antenna offsets in longitudinal direction
W	faktor_N	Odometry and antenna offsets in lateral direction
X	Winkel_V_ONS	Angle calculated with factor_M and factor_N [°]
Y	Winkel_Tr	Angle calculation between current and latest transponder based on the values in the transponder table
Z	Odo_Rechnung_1.dW_Neu	Odometry- based angle for antenna 1 since current transponder [°]
AA	Odo_Rechnung_1.dX_Neu	Odometry- based X position for antenna 1 since current transponder
AB	Odo_Rechnung_1.dY_Neu	Odometry- based distance traveled for antenna 1 since current transponder [m]
AC	Odo_Rechnung_1.dSumme_Weg	Odometry-based angle for antenna 1 since last transponder [°]
AD	Odo_Rechnung_1a.dW_Neu	Odometry-based angle for antenna 1 since last transponder [m]
AE	Odo_Rechnung_1a.dX_Neu	Odometry-based X position of antenna 1 since last transponder [m]

Table 31 Errorlogger: Vehicle Status (part 2 of 7)

Column	Name	Description
AF	Odo_Rechnung_1a.dY_Neu	Odometry- based Y position for antenna 1 since last Transponder [m]
AG	Odo_Rechnung_1a.dSumme_Weg	Odometry- based distance traveled for Antenna 2 since last transponder [m]
AH	Odo_Rechnung_2.dW_Neu	Odometry-based for antenna 2 since current transponder [°]
AI	Odo_Rechnung_2.dX_Neu	Odometry-based X position for antenna 2 since current transponder [m]
AJ	Odo_Rechnung_2.dY_Neu	Odometry- based for antenna 2 since actual transponder [m]
AK	Odo_Rechnung_2.dSumme_Weg	Odometry-based distance traveled for antenna 2 since current transponder [m]
AL	Odo_Rechnung_2a.dW_Neu	Odometry-based angle for antenna 2 since last transponder [°]
AM	Odo_Rechnung_2a.dX_Neu	Odometry-based X position for antenna 2 since last transponder [m]
AN	Odo_Rechnung_2a.dY_Neu	Odometry-based Y position for antenna2 since last transponder [m]
AO	Odo_Rechnung_2a.dSumme_Weg	Odometry-based distance for antenna 2 since last transponder [m]
AP	Calc_counter	Counts the number of calculations already carried out
AQ	Int1_counter	Counts the number of position impulses of antenna 1
AR	Int2_counter	Counts the number of position impulses of antenna 2
AS	Zustand_Antenne_1	Status of Antenna1: 1. position impulse carried out 2. not used 3. Transponder too close or side lobe 4. Antenna switched off
AT	Zustand_Antenne_2	Status of Antenna 2: 1. position impulse carried out 2. not used 3. Transponder too close or side lobe 4. Antenna switched off
AU	Zustand_Rechnung_1	Status of positioning calculation with Antenna 1 0: no calculation 1: single measurement 2: double measurement

Table 31 Errorlogger: Vehicle Status (part 3 of 7)

Column	Name	Description
AV	Zustand_Rechnung_2	Status of position calculation with antenna 2: 0: no calculation 1: single measurement 2: double measurement
AW	t_Spannung_1	Signal strength generated by the transponder antenna 1 (should be > 400)
AX	t_Spannung_2	Signal strength generated by the transponder antenna 2 (should be > 400)
AY	Odo.siSpeed	Actual velocity [m/s]
AZ	Richtung	Direction 1: forward -1: backward
BA	last_t_dy_1	Position of last transponder lateral to direction of travel underneath antenna 1 [m]
BB	last_t_code_1	Transponder code of the last transponder read by antenna 1
BC	last_t_dy_2	Position of the last transponder lateral to direction of travel underneath antenna 2 [m]
BD	last_t_code_2	Transponder code of the last transponder read by antenna 2
BE	Fehler_Counter_5	Error counter for single measurements with antenna 1 Constant: everything OK +1: distance of transponders does not fit +10: direction not OK (parameter) - Distance of transponders too small (parameter) - Same transponder code as before
BF	Fehler_Counter_6	Error counter for double measurement with Antenna 1 Constant: everything OK +1: transponder distance does not fit +10: direction not OK (parameter) - Distance of transponders too small (parameter) - Same transponder code as before

Table 31 Errorlogger: Vehicle Status (part 4 of 7)

Column	Name	Description
BG	Fehler_Counter_7	Error counter for single measurement with antenna 2 Constant: everything OK +1: transponder distance does not fit +10: direction not OK (parameter) - Distance of transponders too small (parameter) - Same transponder code as before
BH	Fehler_Counter_8	Error counter for single measurement with antenna 2 Constant: everything OK +1: transponder distance does not fit +10: direction not OK (parameter) - Distance of transponders too small (parameter) - Same transponder code as before
BI	Fehler_Tr_	Saves the last incorrect transponder distance
BJ	Fehler_MN_	Saves the last incorrect odometry distance
BK	last_t_x_1	t_x_1 of the last transponder
BL	last_t_y_1	t_y_1 of the last transponder
BM	last_t_offset_x_1	T_offset_x_1 of the last transponder
BN	t_offset_x_1	Offset in X direction of transponder antenna 1 to the vehicle's zero point
BO	last_t_offset_y_1	T_offset_y_1 of the last transponder
BP	t_offset_y_1	Offset in Y direction and lateral transponder distance of the transponder antenna 1 to the vehicle's zero point
BQ	last_t_x_2	t_x_2 of the last transponder
BR	last_t_y_2	t_y_2 of the last transponder
BS	last_t_offset_x_2	t_offset_x_2 of the last transponder
BT	t_offset_x_2	Offset in X direction of the transponder antenna 2 to the vehicle's zero point
BU	last_t_offset_y_2	t_offset_y_2 of the last transponder
BV	t_offset_y_2	Offset in Y direction and lateral transponder distance of transponder antenna 2 to the vehicle's zero point
BW	Knickwinkel	Angle of articulation angle sensor [^{o}]
BX	Fehler_Code	Indicates the type of calculation to be carried out: 1: single measurement antenna 1 2: double measurement antenna 1 3 single measurement antenna 2 4: double measurement antenna 2

Table 31 Errorlogger: Vehicle Status (part 5 of 7)

Column	Name	Description
BY	System_Time	Increments every 50 ms, module 16 bits
BZ	o_Lenkwinkel	Actual steering angle of the vehicle
CA	Odo_LenkdW_Neu	Actual steering angle odometry-based [°]
CB	Odo_LenkdX_Neu	Actual position, X component [m] odometry-based
CC	Odo_LenkdY_Neu	Actual position, Y component [m] odomtry- based
CD	Fehler_Quer	Error between odometry and actual calculation in lateral direction
CE	Fehler_Laengs	Error between odometry and actual calculation in longitudinal direction
CF	Fehler_W	Error between odometry and actual angle calculation / angular difference
CG	Fehler_X	Error between odometry and actual calculation in X direction
CH	Fehler_Y	Error between odometry and actual calculation in Y direction
CI	Warte_Posi_Ant_1	Telegram counter antenna 1 A maximum of 3 telegrams between actual position impulse and telegram listed position impulse are allowed. Starts after position impulse with 3 and counts down
CJ	Warte_Posi_Ant_2	Telegram counter antenna 2 A maximum of 3 telegrams between actual position impulse and telegram listed position impulse are allowed. Starts after position impulse with 3 and counts down
CK	Abw_Tab_Winkel_Wert	Maximum allowed angle error (route dependent) [°]
CL	Abw_Tab_Quer_Wert	Maximum allowed lateral error (route dependent) [°]
CM	Abw_Tab_Laengs_Wert	Maximum allowed longitudinal error (route dependent) [°]
CN	Abs_Fehler_W	Absolute error between odometry and actual angular calculation
CO	Abs_Fehler_Quer	Absolute error between odometry and actual calculation in cross direction
CP	Abs_Fehler_Laengs	Absolute error between odometry and actual calculation in longitudinal direction

Table 31 Errorlogger: Vehicle Status (part 6 of 7)

Column	Name	Description
CQ	Sprung_Status	Indicates, why the calculated position was not transferred into odometry - 0x01: Abs_Fehler_W > Abw_Tab_Winkel_Wert - 0x02: Abs_Fehler_Quer > Abw_Tab_Quer_Wert - 0x04: Abs_Fehler_Laengs > Abw_Tab:Laengs_Wert - 0x08: fabs(t_dy_1) > 0.25 m
CR	OdodSumme_Weg	Distance since last used transponder
CS	Genauigkeit	Estimated position accuracy
CT	Guete_Messung	Estimated quality of measurement
CU	Guete_Position	Estimated quality of position in odometry
CV	Guete_Position_Weg	Estimated quality of position in odometry influenced by the distance covered
CW	Gewichtung	Intensity of influence of the calculated position of odometry.
CX	Position_OK	Set to 1, if position was initialized

Table 31 Errorlogger: Vehicle Status (part 7 of 7)

4.11 (G) Parameters Navigation

Using this menu the parameters for the sensor fusion and for the steering controller can be set Following selection screen appears:

```
  Parameter Menu Navigation Controller

  A:  Main
  B:  Geometric
  C:  Accuracy
  D:  Steering
  E:  Steering Controller
  F:  Speed Controller
  G:  Sensorfusion
  H:  Vehicle Specials
  I:  Datalogging




[ESC] -> back/cancel
```

Figure 21 Screenshot: Parameters Navigation

4.11.1 (A) Main

Using this menu the parameters for the sensor fusion and for the steering controller can be set Following selection screen appears:

```
Main Menue -> Parameter Menue -> Main Program Variables


A:  Vehicle Option    (current: Stapler               )
B:  Vehicle Number    (current: 0                     )
C:  RS232 2 Protocoll (current: no Protocoll          )
D:  RS232 2 Baudrate  (current: 9600 Baud             )
E:  RS232 3 Protocoll (current: no Protocoll          )
F:  RS232 3 Baudrate  (current: 115200 Baud           )
G:  RS232 4 Protokoll (current: no Protocoll          )
H:  RS232 4 Baudrate  (current: 9600 Baud             )
I:  CAN 1 Protocoll   (current: CAN Universal         )
J:  CAN 1 Baudrate    (current: 500k Baud             )
K:  CAN 2 Protokoll   (current: Las Rem               )
L:  CAN 2 Baudrate    (current: 250k Baud             )
M:  Fusion Senden     (current: On                    )
N:  Log Seg End       (current: Off                   )
O:  Vehicle Symetrie  (current: Off                   )
P:  Sensorfusion      (current: Extern Laser          )
Q:  Navigation        (current: Off                   )
R:  Simulation        (current: Off                   )
S:  Profibus address  (current: Off                   )
T:  Ethernet IP       (current: Off                   )


[ESC] -> back/cancel
```

Figure 22 Screenshot: Parameters Navigation > Main Menu

The different parameters are described below:

Key	Name	Description
A	Vehicle Option	The vehicle option adjusts basic vehicle parameters: odometry, geometry, trailer, vehicle related outputs etc. (see reference manual)
B	Vehicle Number	Number of the vehicle, e.g. important for data logging
C	RS232 2 Protocol	Protocol of serial interface 2 - camera: PMD Camera - Remote control: for remote control via RS 232 (basic features) - SICK scanner: reading angles and distances
D	RS 232 2 Baudrate	Baud rate of serial interface 2: 9600, 19200, 38400, 57600, 115200 are the options For all baud rates, the parameters are: 8 data bits, no parity, one stop bit
E	RS232 3 Protocol	Protocol of the serial interface 3 - Laser scanner: Götting laser scanner - Sky-Trax: Sky-Trax camera - SICK position: pre-processed SICK position

Table 32 Parameters Navigation > Main Menu (part 1 of 3)

Key	Name	Description
F	RS 232 3 Baudrate	Baud rate of serial interface 3 - 9600, 19200, 38400, 57600, 115200 are the options - For all baud rates, the parameters are: 8 data bits, no parity, one stop bit
G	RS232 4 Protocoll	Protocol of the serial interface 4 - Convoi leader: leading vehicle for convoi mode - Convoi chaser: following vehicle for convoi mode - Ballet protocol: remote control for several vehicles
H	RS 232 4 Baudrate	Baud rate of serial interface 4 - 9600, 19200, 38400, 57600, 115200 are the options - For all baud rates, the parameters are: 8 data bits, no parity, one stop bit
I	CAN 1 Protokoll	Protocol CAN 1, the following protocols are currently available: - CAN Universal, the standard protocol - CAN Daimler - CAN Fendt
J	CAN 1 Baudrate	Baud Rate of CAN interface: 100k, 125k, 250k 500k and 10000k are possible
K	CAN 2 Protokoll	Protocol CAN 2, the following protocols are available: - Ser.: CAN steering servo (Berger-Lahr/Lenze) - Las: Götting laser scanner - Kni: Articulation angle sensor - Kam: Götting optical line tracker camera - Rem: Remote control via CAN
L	CAN 2 Baudrate	Baud Rate of CAN interface 2: 100k, 125k, 250k 500k and 10000k are possible
M	Fusion Senden	Data of the internal sensor fusion is put on the CAN bus (CAN Message Identifier 0x192 and 0x193)
N	Log Seg End	Steering controller keeps a once reached segment end, even if the vehicle slides backwards
O	Vehicle Symmetrie	If this parameter is released, it is possible to move symmetrical vehicles (e.g. with symmetrical steering) from both sides onto the guidance line
Q	Navigation	Releases the steering controller

Table 32 Parameters Navigation > Main Menu (part 2 of 3)

Key	Name	Description
R	Simulation BR	Can be switched on for debuging purposes. Sensor fusion will then be stopped. The steering controller calculates its position using the selected segments.
S	Profibus address	- Profibus Adress: 0 to 126 - At Profibus address 127 the bus is switched off
T	Ethernet IP	- Ethernet IP: 1.1.1.1 up to 255.255.255.255. - At IP 0.0.0.0. ethernet is switched off

Table 32 Parameters Navigation > Main Menu (part 3 of 3)

4.11.2 (B) Geometric

This menu enables setting the geometry of the steering controller and the sensor fusion.

```
Main Menue -> Parameter Menue -> Main Geometri Variables

A:  Achseabstand      (current: 1.200000        [ m ] )
B:  Radabstand        (current: 0.397000        [ m ] )
C:  Raddurchmesser Li (current: 0.270000        [ m ] )
D:  Raddurchmesser Re (current: 0.270000        [ m ] )
E:  Inkremente/Umdreh (current: 2300.000000     [   ] )
F:  Antenne 1 X       (current: 0.810000        [ m ] )
G:  Antenne 1 Y       (current: 0.000000        [ m ] )
H:  Antenne 2 X       (current: 0.000000        [ m ] )
I:  Antenne 2 Y       (current: 0.000000        [ m ] )
J:  Versatz Lenkung   (current: 0.000000        [ m ] )
K:  Antennen invert.  (current:                 [   ] )
L:  Sky Trax  X       (current: -0.340000       [ m ] )
M:  Sky Trax  Y       (current: 0.000000        [ m ] )

[ESC] -> back/cancel
```

Figure 23 Screenshot: Parameters Navigation > Geometric

The following table explains those parameters:

Key	Name	Description
A	Achsabstand	Describes the distances between the symmetrical axis (perpendicular to the vehicle through the center of the circle in curves) and the steered axis.
B	Radabstand	Distance between the centre of right wheel and centre of left wheel
C	Raddurchmesser Links	Effective diameter of the left wheel at a given resolution of the encoder. If the encoder rotates with the same rotational speed as the wheel, then the effective diameter is the same as the wheel diameter. If the rotational speed is different, (e.g. encoder runs on the inner side) the ratio of the rotational speed has to be considered for effective diameter setting!

Table 33 Parameters Navigation > Geometric (part 1 of 2)

Key	Name	Description
D	Raddurchmesser Rechts	Effective diameter of the right wheel at a given resolution of the encoder. If the encoder rotates with the same rotational speed as the wheel, then the effective diameter is the same as the wheel diameter. If the rotational speed is different, (e.g. encoder runs on the inner side) the ratio of the rotational speed has to be considered for effective diameter setting!
E	Inkremente/Umdreh	Resolution of the rotary encoder
F	Antenne 1 X	Offset between the center of the symmetrical axis and the transponder antenna 1 in X direction of the vehicle coordinate system
G	Antenne 1 Y	Offset between the center of the symmetrical axis and the transponder antenna 1 in Y direction of the vehicle coordinate system
H	Antenne 2 X	Offset between the center of the symmetrical axis and the transponder antenna 2 in X direction of the vehicle coordinate system
I	Antenne 2 Y	Offset between the center of the symmetrical axis and the transponder antenna 2 in Y direction of the vehicle coordinate system
J	Versatz Lenkung	It is possible to set an offset if the steering is not located in the center of the vehicle, e.g. for some of the simple forklifts
K	Antennen invert.	Enables inverting the antennas individually. The following combinations are possible: - T1: Transponder antenna 1 - T2: Transponder antenna 2 - SX: Sky Trax in X direction - SY: Sky Trax in Y direction
L	Sky Trax X	Offset between the centre of the symmetrical axis and the position of the Sky Trax camera in X direction of the vehicle coordinate system
M	Sky Trax Y	Offset between the centre of the symmetrical axis and the position of the Sky Trax camera in Y direction of the vehicle coordinate system

Table 33 Parameters Navigation > Geometric (part 2 of 2)

4.11.3 (C) Accuracy

This menu allows adjusting thresholds, where the vehicle shall be stopped.

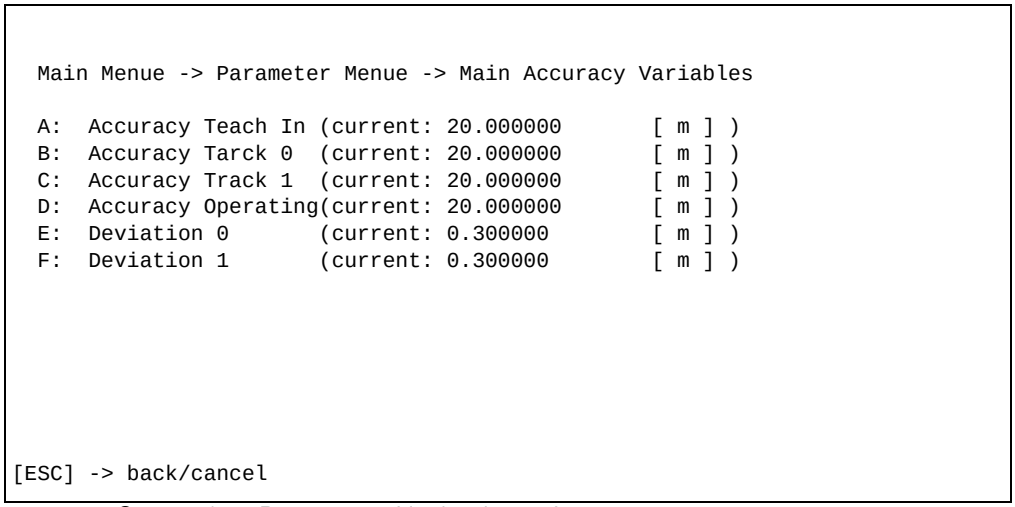

Main Menue -> Parameter Menue -> Main Accuracy Variables
A: Accuracy Teach In (current: 20.000000 [m])
B: Accuracy Tarck 0 (current: 20.000000 [m])
C: Accuracy Track 1 (current: 20.000000 [m])
D: Accuracy Operating(current: 20.000000 [m])
E: Deviation 0 (current: 0.300000 [m])
F: Deviation 1 (current: 0.300000 [m])
[ESC] -> back/cancel

Figure 24 Screenshot: Parameters Navigation > Accuracy

When entering the code for the accuracy it is essential to pay attention to the type of navigation system. The set value indicates the possible error the position may have:

- If the vehicle is navigated with DGPS, the position is always available. If, e.g. an accuracy of 0,05 meter is set, the vehicle will be stopped if the GPS outputs a position accuracy of 0,07 meters.
- If a transponder system is used, the position accuracy is determined differently. Once a transponder has been crossed and the accuracy was good, the accuracy is set to 0,01 meters. With each traveled meter, the accuracy decreases. E.g. if a distance of 10 meters shall be allowed without Transponder reading, the value 0,5 meters (code 16) has to be set in the parameters. If 0,01 meters is set (code 15), 1 meter is allowed. If 0,02 meters is set, (code 14), 2 meters are allowed, with 0,03 meters set, the vehicle will be allowed to travel 3 meters etc.
- For the sensor fusion, it is important that the accuracy is set to a value that allows for one transponder to be missed, while the next one can still be reached safely.
- At a transponder distance of e.g. **3 meters**, corresponding to **7 meters travelling ⇨ Code 9 ⇨ 0,15 meters accuracy**.

The particular parameters are described below:

Key	Name	Description
A	Accuracy Teach In	Minimal necessary accuracy of the position for starting Teach In procedure (Note: Teach In is not yet implemented)
B	Accuracy Track 0	Minimal necessary accuracy of the position for automatic operation, if the attribute is ATTRIBUT_ABWEICHUNGS_UMSCHALT = 0
C	Accuracy Track 1	Minimal accuracy of the position for automatic operation, if the attribute is: ATTRIBUT_ABWEICHUNGS_UMSCHALT = 1
D	Accuracy Operating	Minimal accuracy of the position for starting automatic operation
E	Deviation 0	Maximal allowed deviation between actual and target position for automatic operation if the attribute is: ATTRIBUT_GENAUIGKEITS_UMSCHALT = 0
F	Deviation 1	Maximal allowed deviation between actual and target position for automatic operation if the attribute is: ATTRIBUT_GENAUIGKEITS_UMSCHALT = 1

Table 34 Parameters Navigation > Accuracy

4.11.4 (D) Steering

This submenu enables setting all parameters for steering. The first 3 parameters refer directly to the steering controller.

NOTE! If the steering is controlled by a vehicle control unit, it is essential to indicate the scaling of the steering, Comp. Left 1 and Comp. Right 1!

```
Main Menue -> Parameter Menue -> Angle Controller Variables

A:  Steering min      (current: 0              [   ] )
B:  Steering Middle   (current: 0              [   ] )
C:  Steering max      (current: 0              [   ] )
D:  Steering Scaling  (current: 100.000000     [   ] )
E:  Comp. Left 2      (current: 0.000000       [   ] )
F:  Comp. Left 1      (current: 1.000000       [   ] )
G:  Comp. Middel      (current: 0.000000       [   ] )
H:  Comp. Right 1     (current: 1.000000       [   ] )
I:  Comp. Right 2     (current: 0.000000       [   ] )
J:  Servo Typ         (current: Lenze          [   ] )




[ESC] -> back/cancel
```

Figure 25 Screenshot: Parameters Navigation > Steering

4.11.4.1 Parameters

The following table explains the parameters:

Key	Name	Descriptio
A	Steering min	Lowest limit of steering
B	Steering Middle	Center setting of steering
C	Steering max	Upper limit of steering
D	Steering Scaling	Resolution of steering on interface: if the angle is transmitted with of 1/ 100°, the parameter must be 100
E	Comp. Left 2	Square term of steering correction for left turn
F	Comp. Left 1	Linear term of steering correction for left turn
G	Comp. Middel	Center setting of steering correction
H	Comp. Right 1	Linear term of steering correction for right turn
I	Comp. Right 2	Square term of steering correction for right turn
J	Servo Typ	Enables setting the connected steering servo. Supported are Lenze and Berger Lahr

Table 35 Parameters Navigation > Steering

4.11.4.2 Steering correction

Steering correction is to improve the steering accuracy. If for example a steering trapezoid is used, then the inaccuracy increases with the degree of the angle. To compensate for any inaccuracies and deviations, the following procedures may be used:

1. Travel a straight line with the vehicle and measure the necessary steering angle.
2. Travel a left turn with ¼ of the maximal steering angle, measure the circle diameter and calculate the theoretical steering angle with arctangent (axle distance/curve radius)
3. Travel left turn with 2/4 of the maximal steering angle, measure the circle diameter and calculate the theoretical steering angle with arctangent (axle distance/curve radius)
4. Travel left turn with 3/4 of the maximal steering angle, measure the circle diameter and calculate the theoretical steering angle with arctangent (axle distance/curve radius)
5. Travel left turn with 4/4 of the maximal steering angle, measure the circle diameter and calculate the theoretical steering angle with arctangent (axle distance/curve radius)
6. Repeat points 2 through 5 for the right turn
7. Display the theoretical and the actual steering angles in a point diagram
8. Then insert a 2nd degree polynomic trend line and have the equation displayed
9. The above listed steps lead to the diagram below and the equation provides the needed correction coefficients.

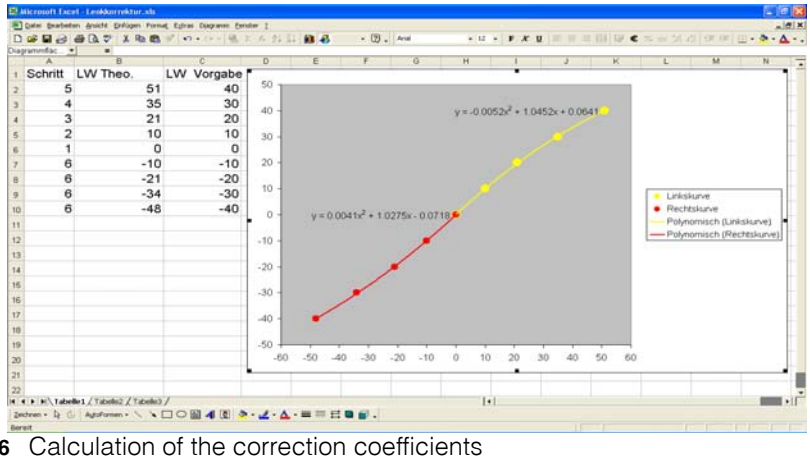


Figure 26 Calculation of the correction coefficients

Column A describes the required steps, column B the theoretical steering angles and column C the given steering angles. `Comp. Middel` is the average offset of both equations (see Table 35 on page 56).

4.11.5 (E) Stering Controller

The steering angle controller calculates the steering angle, required to follow the intended track. This controller consists of two parts:

1. The first part is a feed back controller in the traditional sense. It is possible to parameterize this angle controller using the parameters A-D, P, PI or PDT1. The output of the controller can be limited via the parameters G and H. This controller is only used for some vehicles for special tasks.

2. The second part is the actual feed back controller of the steering controller. Normally the vehicle is steered by this controller. It works on straight lines only (cornering is achieved via overlaying a curve feed forward control). The controller always calculates the steering angle to point to a section on the nominal track in front of the vehicle.

If the steering of the vehicle is directly connected to the steering controller, it is possible to activate a steering servo. The steering servo is an subordinate controller triggered every 5 ms. It controls the steering motor in such a way that the desired steering angle will be adjusted (proportional controller).

```
  Main Menue -> Parameter Menue -> Angle Controller Variables

  A:  Angle Control Kp  (current: 12.000000       [   ] )
  B:  Angle Control Tn  (current: 0.000000        [   ] )
  C:  Angle Control Tv  (current: 3.000000        [   ] )
  D:  Angle Control Td  (current: 0.010000        [   ] )
  E:  Speed Comp. Fix   (current: 1.000000        [   ] )
  F:  Speed Comp. Var   (current: 0.000000        [   ] )
  G:  lower Limit       (current: -200.000000     [ ° ] )
  H:  higher Limit      (current: 200.000000      [ ° ] )
  I:  I Max             (current: 1.000000        [   ] )
  J:  I Min             (current: -1.000000       [   ] )
  K:  Typ               (current: 0               [   ] )
  L:  forward dis. Fix  (current: 1.500000        [ m ] )
  M:  forward dis. Var  (current: 0.200000        [ m ] )
  N:  Approach Lim. Fix (current: 10.000000       [ ° ] )
  O:  Approach Lim. Var (current: 0.100000        [ ° ] )
  P:  Steeringangle Max (current: 90.000000       [ ° ] )
  Q:  Steerung Servo    (current: Off                   )
  R:  Steering Servo KP (current: 50.000000       [   ] )


[ESC] -> back/cancel
```

Figure 27 Screenshot: Parameters Navigation > Steering Controller

The single parameters are described in the following table:

Key	Name	Description
A	Angle Control Kp	Linear amplification of the angle control (first part of the steering angle controller) applied at the following vehicle options: ABU, ABE (see reference manual)
B	Angle Control Tn	Integration time constant of the angle control (first part of the steering angle controller) applicable for the following vehicle options: ABU, ABE (see reference manual)
C	Angle Control Tv	Derivative time of the angle control (first part of the steering angle controller) applicable for the following vehicle options: ABU, ABE (see reference manual)
D	Angle Control Td	Differentiation time constant of the angle control (first part of the steering angle controller) applicable for the following vehicle options: ABU, ABE (see reference manual)
E	Speed Comp. Fix	Constant proportion of the gradient of the steering angle ramp in ^{o} / 50ms. The steering angle ramp is only used with guide wire sensors or in parameter test mode

Table 36 Parameters Navigation > Steering Controller (part 1 of 2)

Key	Name	Description
F	Speed Comp. Var	Variable proportion of the gradient of the steering angle ramp in ° / 50ms (multiplied by the vehicle velocity in m/s).
G	lower Limit	Lower limit of the angle control (first part of the steering angle controller)
H	higher Limit	Upper limit of the angle control (first part of the steering angle controller)
I	I Max	Sets maximum permissible value of the integral proportion of the controller
J	I Min	Sets minimum permissible value of the integral proportion of the controller
K	Typ	Controller type: **Should always be set to 0** (PID controller with parameterizable parts (see point A - D))
L	forward dis. Fix	Velocity independent part of the track from the intersection point of the vehicle's symmetry axis with the nominal track up to the point of the nominal track to which the steered wheels are directed at (second part of the steering angle controller)
J	forward dis. Var	Velocity dependent part of the track from the intersection point of the vehicle's symmetry axis with the nominal track up to the point of the nominal track to which the steered wheels are directed at (second part of the steering angle controller)
K	Approach Lim. Fix	Maximum angle between the nominal track and the steered wheels (velocity dependent; second part of the steering angle controller)
L	Approach Lim. Var	Maximum angle between the nominal track and the steered wheels (velocity independent, second part of the steering angle controller)
M	Steeringangle Max	Limitation of the calculated steering angle (second part of the steering angle controller)
N	Steering Servo	Switch on / off of the steering servo
O	Sterring Servo Kp	Amplification of the steering servo (proportional controller)

Table 36 Parameters Navigation > Steering Controller (part 2 of 2)

4.11.6 (F) Speed Controller

The speed controller is not yet used in any vehicle. Up to this point the speed control is accomplished by the vehicle control unit.

```
Main Menue -> Parameter Menue -> Speed Controller Variables

A:  Speed Control Kp  (current: 100.000000      [   ] )
B:  Speed Control Tn  (current: 0.000000        [   ] )
C:  Speed Control Tv  (current: 0.000000        [   ] )
D:  Speed Control Td  (current: 0.000000        [   ] )
E:  Speed Comp. Fix   (current: 420.000000      [   ] )
F:  Speed Comp. Var   (current: 300.000000      [   ] )
G:  lower Limit       (current: -1550.000000    [ ° ] )
H:  higher Limit      (current: 1500.000000     [ ° ] )
I:  I Max             (current: 100.000000      [   ] )
J:  I Min             (current: -100.000000     [   ] )
K:  Typ               (current: 0               [   ] )
L:  Ringspeicher Peri (current: 0               [   ] )
M:  Wert Schaetzer    (current: 0.000000        [   ] )
N:  Differenz Eingriff(current: 0.000000        [   ] )
O:  Zu hoch Wert      (current: 0.000000        [   ] )
P:  Zu hoch Perioden  (current: 0               [   ] )
Q:  Rampe             (current: 1.000000        [   ] )
R:  V Max Vorwaerts   (current: 400.000000      [   ] )


[ESC] -> back/cancel
```

Figure 28 Screenshot: Parameters Navigation > Speed Controller

The different parameters are described in the table below:

Key	Name	Description
A	Speed Control Kp	Linear amplification of the speed controller
B	Speed Control Tn	Integration time constant of the speed controller
C	Speed Control Tv	Derivative time of the speed controller
D	Speed Control Td	Differentiation time constant of the speed controller
E	Speed Comp. Fix	Constant proportion of the gradient of the speed ramp in 1/50 ms
F	Speed Comp. Var	Variable proportion of the gradient of the speed ramp in 1/50 ms (multiplied by the vehicle velocity in m/s)
G	lower Limit	Lower limit of the speed controller (first part of the steering angle controller)
H	higher Limit	Upper limit of the speed controller (first part of the steering angle controller)
I	I Max	Sets maximum permissible value of the integral proportion of the controller
J	I Min	Sets minimum value of the integral proportion of the controller

Table 37 Parameters Navigation > Speed Controller (part 1 of 2)

Key	Name	Description
K	Typ	Controller Type: Should always be set to 0 (PID controller with parameterizable parts (see point A - D))
L	Ringspeicher Peri	Time delay for the cyclic buffer of the velocity estimator (not required for controller type 0)
M	Wert Schaetzer	Expected value of the velocity estimator (not required for controller type 0)
N	Differenz Eingriff	Difference between nominal and actual value activating an increased influence of the controller (not required for controller type 0)
O	Zu hoch Wert	Velocity difference activating brake control (not required for controller type 0).
P	Rampe	For some vehicle options velocity is output via a velocity ramp function. This parameter corresponds to the increment by which the target velocity shall be incremented or decremented every 50ms.
Q	V Max Vorwaerts	Limitation of the forward speed for those vehicles using a velocity ramp.
R	V Max Rueckwaerts	Limitation of the reverse speed for those vehicles applying a velocity ramp.

Table 37 Parameters Navigation > Speed Controller (part 2 of 2)

4.11.7 (G) Sensor Fusion

```
Main Menue -> Parameter Menue -> Sensorfusion Variables


A:  Min Dist. Reading (current: 0.300000        [ m ] )
B:  Min Dist. Single  (current: 0.500000        [ m ] )
C:  Max Dist. Double  (current: 0.000000        [ m ] )
D:  Delta Angle Max   (current: 400.000000      [ ¯ ] )
E:  Delta X Pos Max   (current: 10000.000000    [ m ] )
F:  Delta Y Pos Max   (current: 10000.000000    [ m ] )
G:  Delta Posi. Max   (current: 0.100000        [ m ] )
H:  Max Tol. Tr/ONS   (current: 0.100000        [ m ] )
I:  Single Antenna    (current: On                    )
J:  Single Ant.op.Dir.(current: On                    )
K:  Gyro              (current: On                    )
L:  Primary ONS Typ   (current: 2                     )
M:  Secondary ONS Typ (current: 2                     )
N:  Delta Posi. Max P (current: 0.000000              )
O:  Transp. Ant. Typ  (current: HG 71720              )
P:  Skalierung Sky T. (current: 0.000000              )


[ESC] -> back/cancel
```

Figure 29 Screenshot: Parameters Navigation > Sensor Fusion

The different parameters are described in the following table:

Key	Name	Description
A	Min Dist. Reading	The antenna will only trigger a position impulse if a certain minimum distance is covered. This prevents a side lobe from generating a position impulse.
B	Min Dist. Single	Minimum distance required for positioning calculation between two transponders with one antenna and two different transponders. If the transponder distance is too small, the angular error will be increased due to the transponder antenna's read error rate. If the transponder distance is too large, the error rate increases caused by the inaccuracy of odometry.
C	Max Dist. Double	Maximum distance between the reading of one antenna and the transponder reading of another antenna. The highest measurement accuracy will be guaranteed if both antennas read the same transponder simultaneously.
D	Delta Angle Max	Maximum permissible angle difference between primary odometry and the comparative / reference odometry (secondary odometry). The odometry includes two rotary encoders and one optional gyro. The secondary odometry calculates the position from two rotary encoders and the actual steering angle.
E	Delta X Pos Max	Maximum permissible difference of the X position between primary odometry and secondary odometry.
F	Delta Y Pos Max	Maximum permissible difference of the Y position between primary odometry and secondary odometry.
G	Delta Posi. Max	Maximum permissible difference between odometry based transponder positions and the positions entered in the transponder list.
H	Max Tol. Tr/ONS	Maximum permissible difference between the position based on odometry and the position just calculated. However, if this tolerance level will be exceeded, the result of the position calculation may be able to be used - but the accuracy output will not be increased!
I	Single Antenna	Switch on / switch off of the single measurements
J	Single Ant.op.Dir.	Setting specifies if antennas behind the symmetry axis in direction of travel will be applied.
K	Gyro	Differential odometry without a gyro means that the steering angle is calculated from the difference of the distances of the right and left wheel. The disadvantage is that the steering calculation is strongly load dependent. If a gyro is applied the gyro determines the steering angle. The rotary encoders will be averaged and represent only a lengthwise movement. The advantage is a load independent steering angle.
L	Primary ONS Typ	The position is calculated by the primary odometry.

Table 38 Parameters Navigation > Sensor Fusion (part 1 of 2)

Key	Name	Description
M	Secondary ONS Typ	Secondary odometry is compared to primary odometry. Should large differences between primary and secondary odometry arise (see D, E and F), the accuracy of the internal sensor fusion will be set to a poor value and the vehicle stops. Therefore defective sensors can be detected.
N	Delta Posi. Max P	Maximum permissible differencebetween odometry based transponder positions and the positions provided in the transponder list in percent.
O	Transp. Ant. Typ	Types of transponder antennas: - G 71720: Used for track guidance (lateral displacement will be measured) - G 98767: Not suitable for track guidance (lateral displacement will not be measured). For this antenna an additional guidance or camera system has to be applied.
P	Skalierung Sky T.	The Sky-Trax system specifies exact locations of the tags in pixels. This parameter provides a conversion between pixels and meters. If there are different tag sizes or different heights, a fine tuning adjustment is possible with the tag sizes of the transponder list.

Table 38 Parameters Navigation > Sensor Fusion (part 2 of 2)

4.11.8 (H) Vehicle Specials

This output is vehicle specific. Information is available in the reference manual.

4.11.9 (I) Datalogging (Parameterization of the output)

In this menu the debugging outputs of the steering controller and the sensor fusion can be parameterized. The indicated menu items function only as titles for a different number of issued variables. These various options are necessary as it would last more than 50 ms to issue all variables - this would be too time consuming for the system function. On the other hand failures of different types each require individual variables. Allocation of the variables characterized by a header field with their corresponding names can be taken from the CSV- file.

```
Data Logging

Navigation:                          Sensorfusion:
1: Ist Position             1        H: Inkremente                1
2: Soll Position            0        I: Odometrie 1               0
3: Achs Position            0        J: Odometrie 2               0
4: Hilfs Position           0        K: Odometrie Rechnung 1      0
5: Ziel Position            0        L: Odometrie Rechnung 2      0
6: Abweichungen             0        M: Odometrie Lenkung         0
7: Fehler                   0        N: Transponderantenne 1      0
8: Lenkwinkel               0        O: Transponderantenne 2      0
9: Stuetzpunkt              0        P: Voraussetzungen           0
A: Segmente Rx              0        Q: Genauigkeiten             0
B: Segmente Tx              0        R: Gyro                      0
C: Richtung                 0        S: Gewichtungen              0
D: Genauigkeit              0        T: PMD Ausgabe               0
E: Mesungen BR              0        U: Odometrie                 1
F: Fahrzeug Abh.1           0        V: Sky Trax                  0
G: Segmentsuche             0        W: fahrend loggen            0


[ESC] -> back/cancel
```

Figure 30 Screenshot: Parameters Navigation > Datalogging

Due to the amount of data please see the table with complete listing in the reference manual.

4.12 Display and key pad of the control unit

The display of the control unit provides an overview on the operating status of the steering controller, even without a laptop.

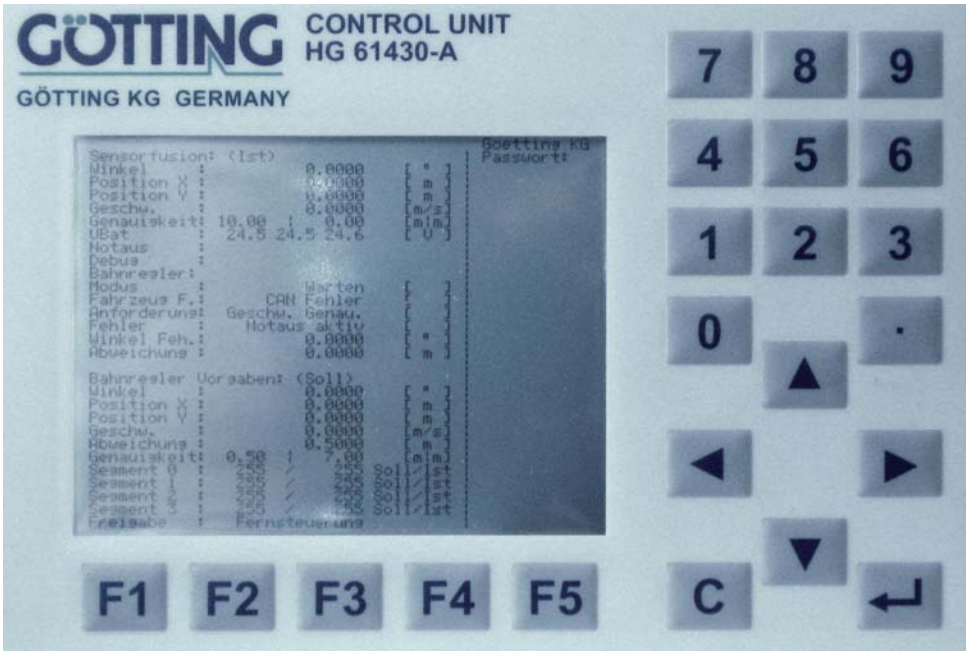


Figure 31 Display of the control unit HG 61430

NOTE! Before entering the password only the displayed values are available.

4.12.1 Status output on the Display

The section "Sensorfusion" provide the following data:

Name	Description	Unit
Winkel	Angle of vehicle odometry	[°]
Position X	X position of vehicle odometry	[m]
Position Y	Y position of vehicle odometry	[m]
Geschw.	Velocity of vehicle odometry	[m/s]
Genauigkeit	On the left: accuracy of sensor fusion On the right: traveled distance since the last referencing	[m]

Table 39 Display Control Unit: Section Sensor Fusion (part 1 of 2)

Name	Description	Unit
Ubat	Left: minimum supply voltage value Center: current value of supply voltage Right: maximum value of supply voltage *Minimum and Maximum values adjust themselves to the current value within a short time.*	[V]
Nothalt	See emergency stop (reference manual)	[ ]
Debug	See error automatic drive (reference manual)	[ ]

Table 39 Display Control Unit: Section Sensor Fusion (part 2 of 2)

The section "Bahnregler (steering controller)" displays the following:

Name	Description	Unit
Modus	See section vehicle options in the reference manual	[ ]
Fahrzeug F.	See section error code in the reference manual	[ ]
Anforderung	See section error code in the reference manual	[ ]
Fehler	See section error code in the reference manual	[ ]
Winkel Feh.	Error of heading	[°]
Abweichung	Lateral displacement to the segment	[m]

Table 40 Display Control Unit: Section Bahnregler

The section "Bahnregler Vorgaben (steering controller default values)" indicates the target values.

Name	Description	Unit
Winkel	Set angle of the steering controller	[°]
Position X	Target position of the steering controller in X direction	[m]
Position Y	Target position of the steering controller in Y direction	[m]
Geschw.	Target velocity of the steering controller	[m/s]
Abweichung	Maximum permissible displacement at this position (depending on the attribute)	[m]
Genauigkeit	Left: worst permissible accuracy in meters Right: worst permissible accuracy coded in the output telegram.	[m][ ]
Segment 0	Left: segment 0 preset by the vehicle controller (current segment) Right: segment 0 processed by the steering controller (current segment)	[ ]

Table 41 Display Control Unit: Section Bahnregler Vorgaben (part 1 of 2)

Name	Description	Unit
Segment 1	Left: Segment 1 preset by the vehicle controller (next upcoming segment) Right: segment 1 processed by the steering controller (next upcoming segment)	[ ]
Segment 2	Left: segment 2 preset by the vehicle controller (next segment after next) Right: segment 2 processed by the steering controller (next segment after next)	[ ]
Segment 3	Left: segment 3 preset by the vehicle controller Right: segment 3 processed by the steering controller	[ ]
Freigabe	Remote control: Central control unit has access to the vehicle. Manually operated: Central control unit cannot access the vehicle.	[ ]

Table 41 Display Control Unit: Section Bahnregler Vorgaben (part 2 of 2)

4.12.2 Direct input options at the control unit

If you enter password **222555** the following input mask will be displayed to the right of vertical dividing line.

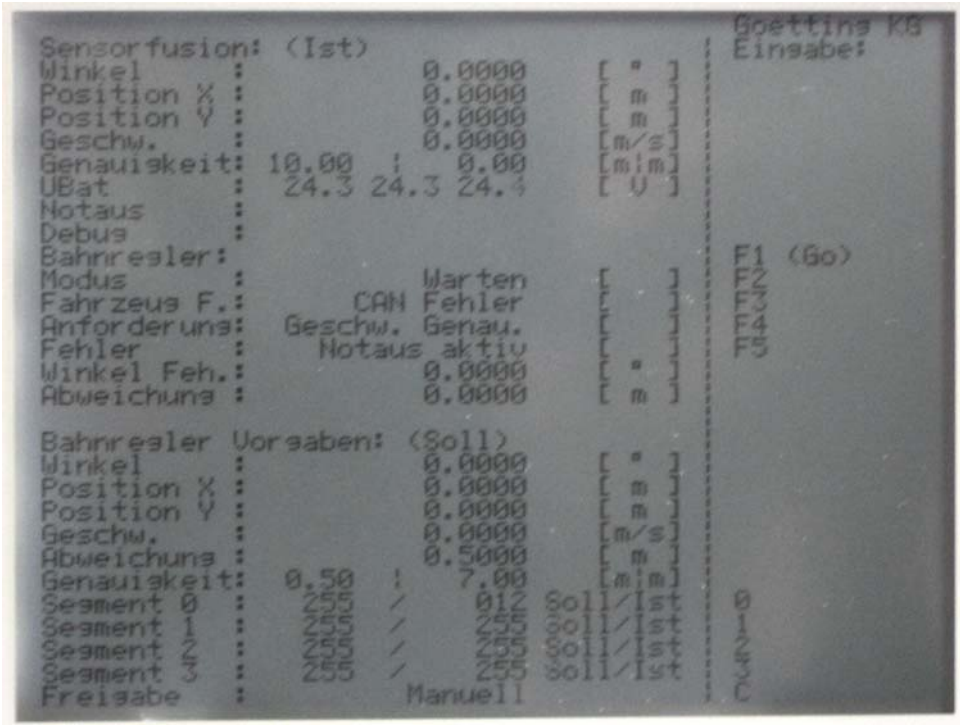

Goetting KG
Sensorfusion: (Ist)
Eingabe:
Winkel : 0.0000 [°]
Position X : 0.0000 [m]
Position Y : 0.0000 [m]
Geschw. : 0.0000 [m/s]
Genauigkeit: 10.00 ! 0.00 [m|m]
UBat : 24.3 24.3 24.4 [V]
Notaus :
Debug :
Bahnregler:
F1 (Go)
Modus : Warten [ ] F2
Fahrzeug F.: CAN Fehler [ ] F3
Anforderung: Geschw. Genau. [ ] F4
Fehler : Notaus aktiv [ ] F5
Winkel Feh.: 0.0000 [°]
Abweichung : 0.0000 [m]
Bahnregler Vorgaben: (Soll)
Winkel : 0.0000 [°]
Position X : 0.0000 [m]
Position Y : 0.0000 [m]
Geschw. : 0.0000 [m/s]
Abweichung : 0.5000 [m]
Genauigkeit: 0.50 ! 7.00 [m|m]
Segment 0 : 255 / 012 Soll/Ist 0
Segment 1 : 255 / 255 Soll/Ist 1
Segment 2 : 255 / 255 Soll/Ist 2
Segment 3 : 255 / 255 Soll/Ist 3
Freigabe : Manuell C

Figure 32 Display after password entry

Now the following input options are displayed to the right of the vertical dividing line.

Name	Description
F1	Toggling start release
F2	Switch mode from driving in automatic mode / standby mode
F3	Browsing of vehicle errors
F4	Browsing of request errors
F5	Browsing of automatic mode errors
0	Preset segment 0
1	Preset segment 1
2	Preset segment 2
3	Preset segment 3
C	Toggling release for vehicle control unit

Table 42 Display Control Unit: Input options

5 Trouble Shooting

Following you will find a tabular listing of any possible malfunctions. This troubleshooting chart lists occurring symptoms and the malfunctions that may be causing the symptoms.

In the third column you'll find instructions how to detect errors and how errors can ideally be resolved.

If it is not possible to resolve the error, before contacting us please isolate the failures as precisely as possible using the table below (type of malfunction, time of occurrence etc.).

Error	Possible causes of failure	Possible diagnosis / trouble-shooting
Velocity incorrectly displayed or set	1. Rotary encoder defective or connected incorrectly. 2. Parameter "increments per revolution" or wheel diameter are wrong 3. Steering angle error: When using odometry with steering angle the vehicle speed is calculated based on the steering angle	1. Check the rotary encoder via menu „(E) Test Monitor“ on page 40 and replace, if necessary 2. Re-adjust odometry (refer to chapter 4 „Commissioning“ on page 28) 3. Check actual angle using menu „(E) Test Monitor“ on page 40
Automatic mode is not accepted / is not executed	1. Vehicle is not close to the selected segment. 2. No start release for the vehicle control unit 3. Errors "Request" or "Vehicle" are displayed in menu "(A) Main Monitor Navigation" on page 33	1. 1.Drive the vehicle to the segment start and use ‘N: Show Segments‘ to compare the coordinate of the corresponding segment with the ones currently displayed 2. Activate release function by pressing button C in menu „(A) Main Monitor Navigation“ on page 32 or use the display (see section „Display and key pad of the control unit“ on page 65) 3. Check the indicated error message in the reference manual, section error code

Table 43 Trouble Shooting (part 1 of 2)

Error	Possible causes of failure	Possible diagnosis / trouble-shooting
Vehicle does not steer	1. Some vehicle types only steer while driving 2. Steering angle not properly parameterized 3. Transmission fault, steering angle not transmitted	1. Try steering while driving 2. Check the following parameters. Make sure, none of the parameters is 0! - D: Steering Scaling - Comp. Left 1 - Comp. Right 1 - E: Speed Comp. Fix - Steering angle Max 3. Check the CAN Box 0x191 with the CAN monitor
Transponder is not evaluated	1. Signal strength of the transponder is too low 2. position impulse missing 3. Not enough distance to other transponders	1. Check ground reinforcement; minimize reading distance; check adjustment of antenna; possible defect of the antenna or transponder. 2. Reduce threshold for antenna position impulse; re-connect antenna properly 3. Relocate the transponder. Adjust parameters
Driving in automatic mode not possible	1. 1.Error is displayed in menu „(A) Main Monitor Navigation“ on page 32 2. Velocity is not transmitted	1. See section error codes in the reference manual 2. Check the CAN box 0x191 with the CAN monitor
Segment list is not accepted	1. No release for vehicle control unit 2. Incomplete sequence of segments (detectable via menu „(A) Main Monitor Navigation“ on page 32 if 0x00008000 is displayed in the section "Condition" 3. Vehicle option is not suitable for segment parameters	1. 1.Activate the release function by pressing button C in menu „(A) Main Monitor Navigation“ on page 32 or trigger the release with the display (see chapter „Display and key pad of the control unit“ on page 65) 2. Load the segments in the correct order and / or correct start points / end points of the segment 3. Select other vehicle options

Table 43 Trouble Shooting (part 2 of 2)

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8 Essential Information for Reading this Manual

In documentations of Götting KG the following symbols and assignments were used at the time of printing this manual:

- Security advices have the following symbols, depending on the emphasis and the degree of exposure:

NOTE!

ATTENTION!

CAUTION!

WARNING!

- Continuative information and tips are identified as follows:

Tip!

- Program texts and variables are highlighted by using the `font 'Courier'`.
- Whenever input of key combinations is required for the operation of programms, the corresponding Keys are Highlighted (in Götting KG programs it is usually possible to use small and capitalized characters equally).
- Sections, figures and tables are automatically numbered consecutively throughout the entire document. In addition, each document has an index listed behind the front page, including pages and - whenever the document has more than 10 pages - following the actual system description a figure and table index in the back. In certain cases (for long and/or complicated documents) a subject index is added.
- Each document provides a table block with metainformation on the front page, indicating the system designer, auther, revision and date of issue. In addition, the information regarding revision and date of issue are included within the footer of each page, enabling the exact allocation of the information with a date and certain a system revision.
- Online-Version (PDF) and printed manual are generated from the same source. Due to the consistent use of Adobe FrameMaker for the generation of documentation, all directory entries (including page numbers and subject index) and cross references in the PDF file can be clicked on with the mouse and will lead to the corresponding linked contents.

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Any information given is to be understood as system description only, but is not to be taken as guaranteed features. Any values are reference values. The product characteristics are only valid if the systems are used according to the description.

This instruction manual has been drawn up to the best of our knowledge. Installation, setup and operation of the device will be on the customer's own risk. Liability for consequential defects is excluded. We reserve the right for changes encouraging technical improvements. We also reserve the right to change the contents of this manual without having to give notice to any third party.

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